THE PRODUCTION ENGINEER

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

OCTOBER 1960

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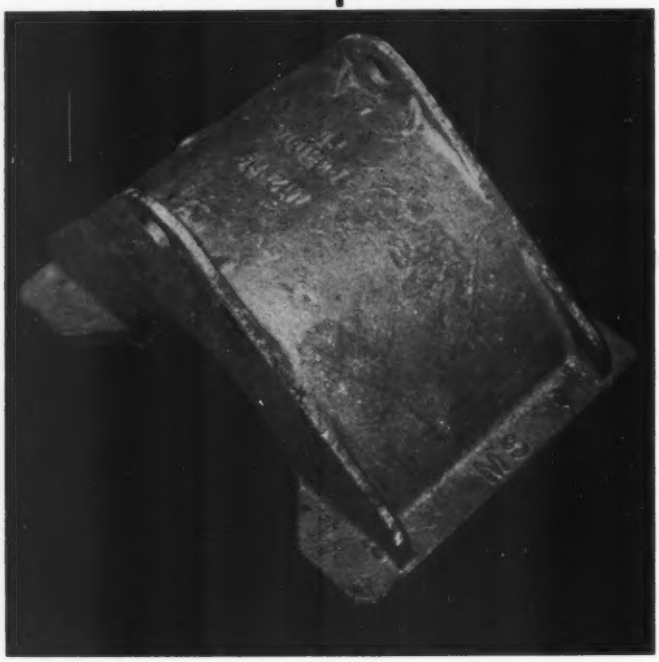

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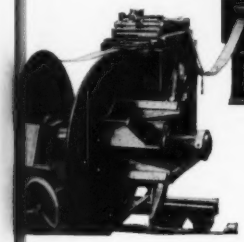

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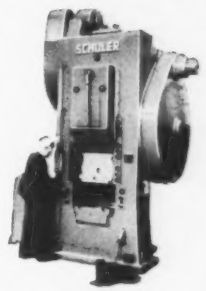

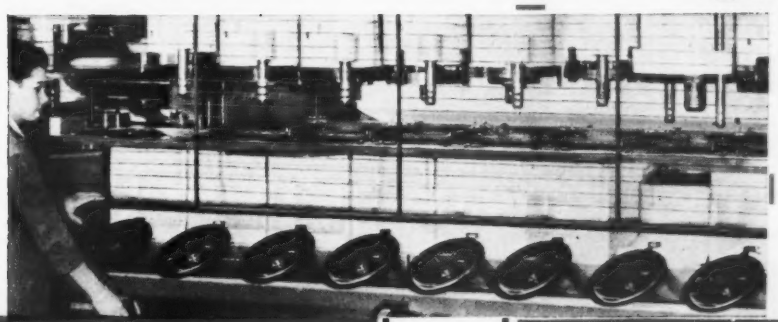

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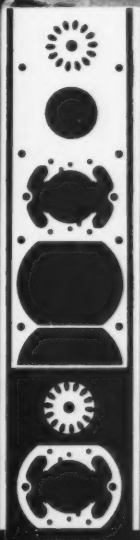

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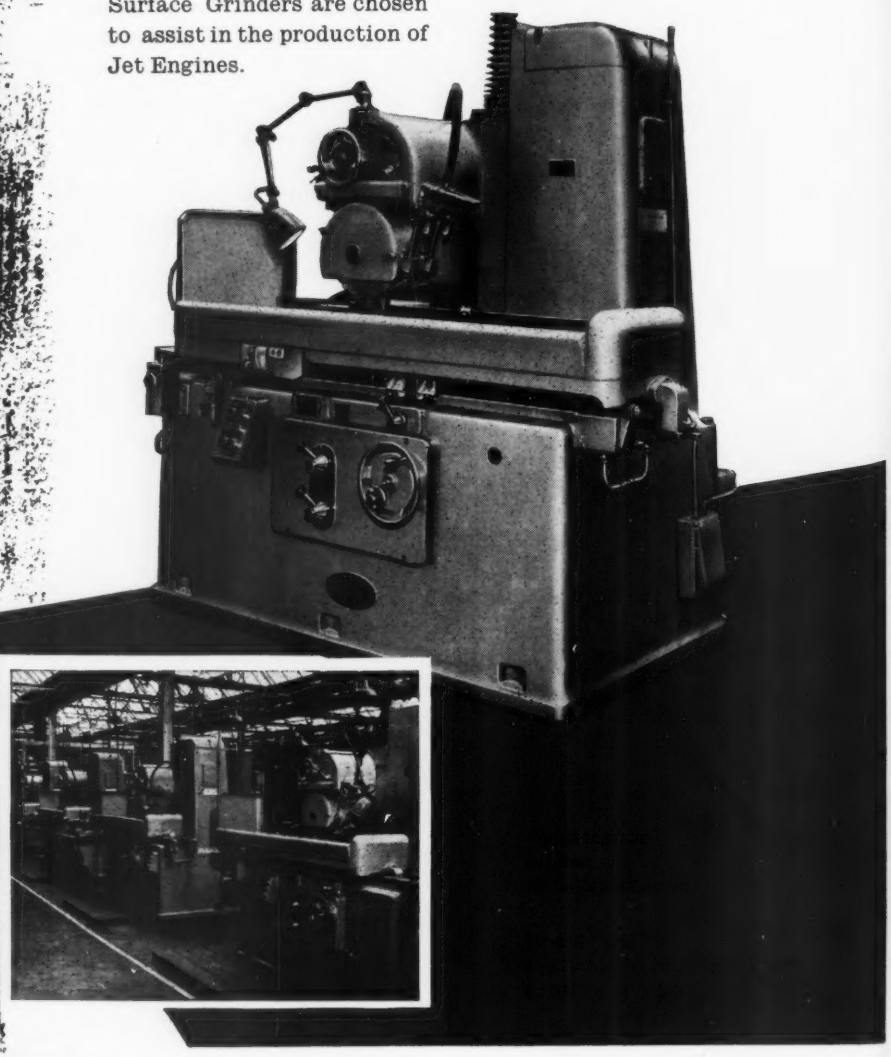

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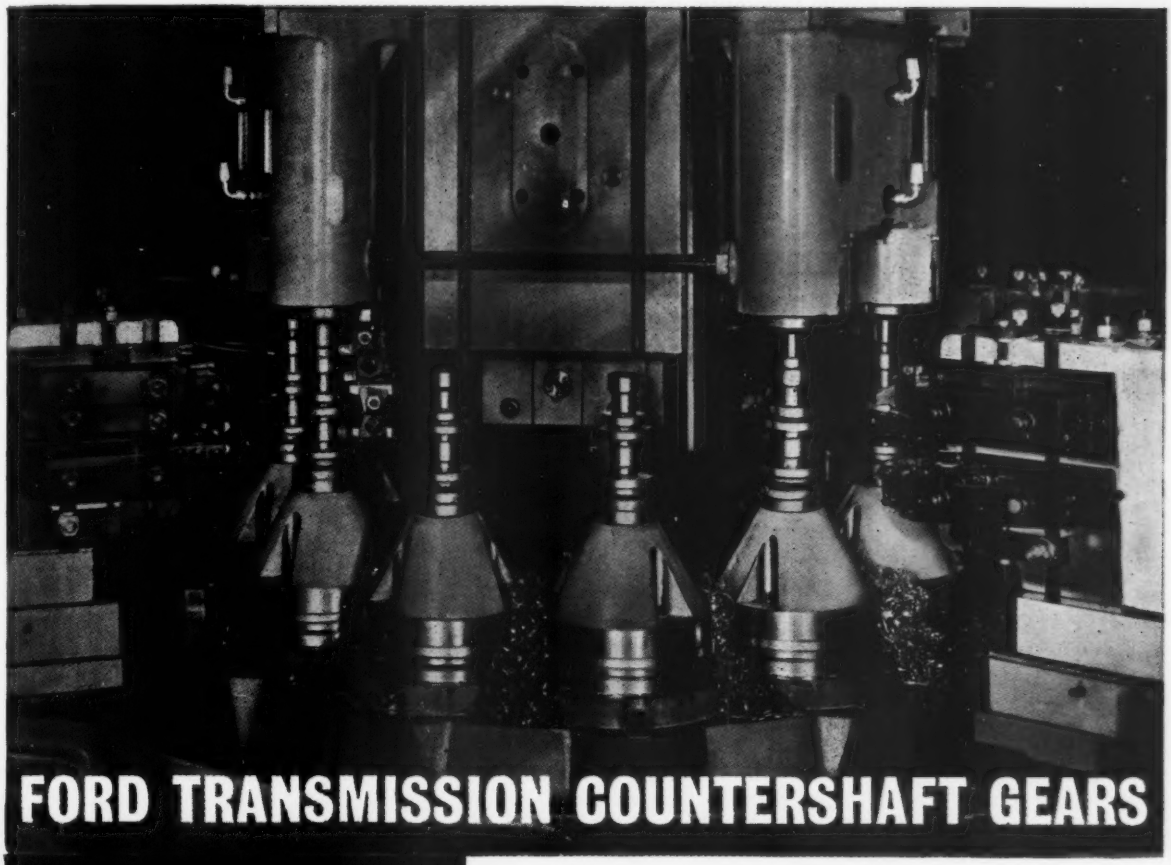
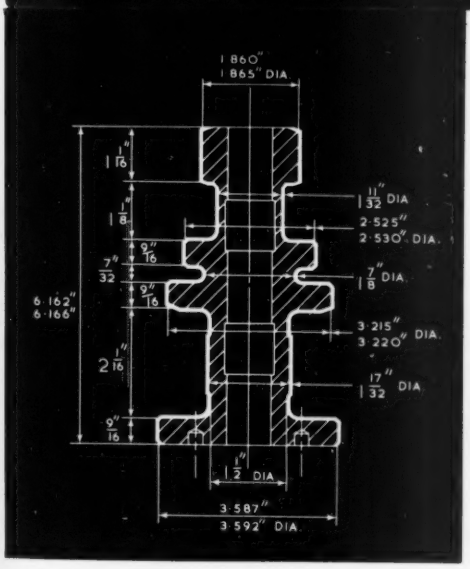


FORD TRANSMISSION COUNTERSHAFT GEARS



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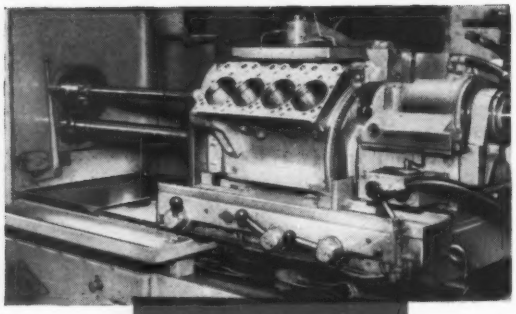
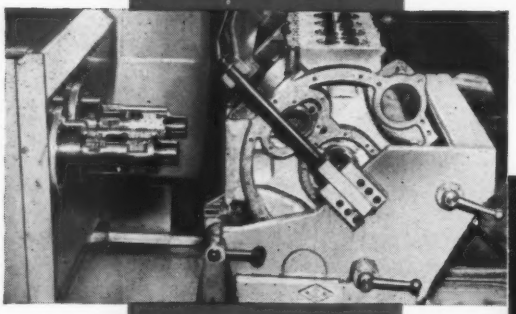
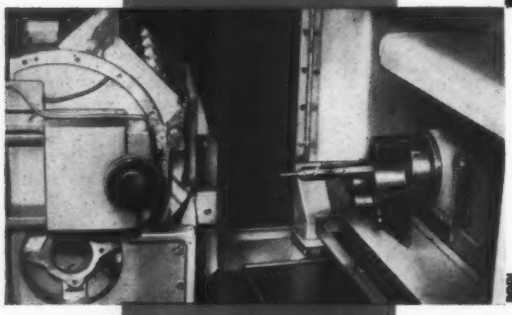


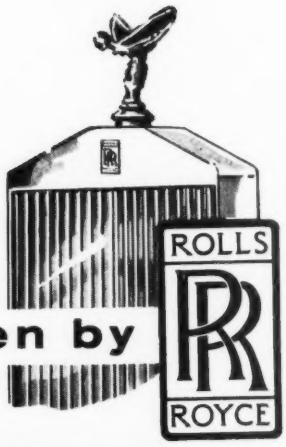
Line boring camshaft and crankshaft bores, and facing, counter-boring and milling of seating on end of crankcase.



Finishing liner bores including grooving operation.



Boring and milling on drive take off holes and faces.



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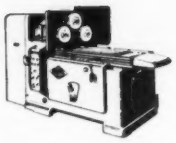

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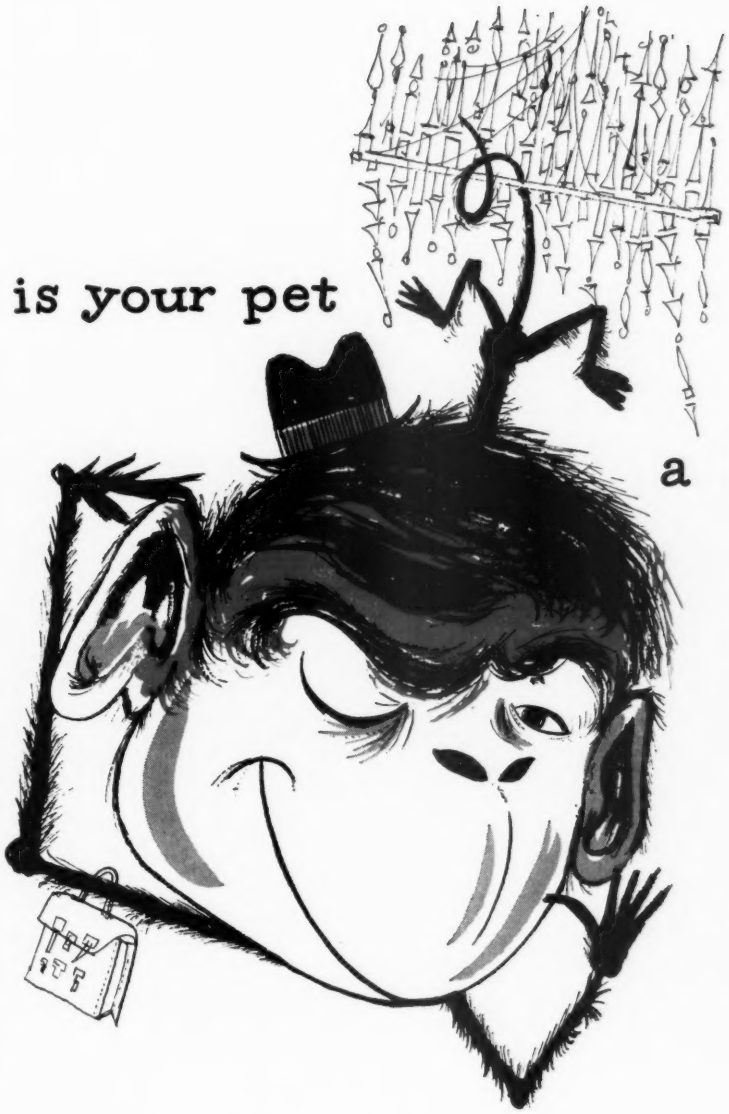

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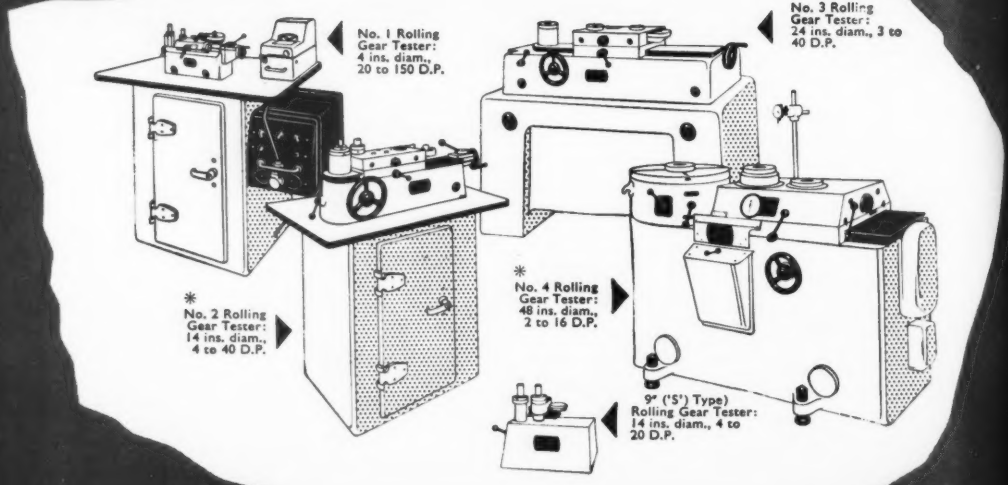
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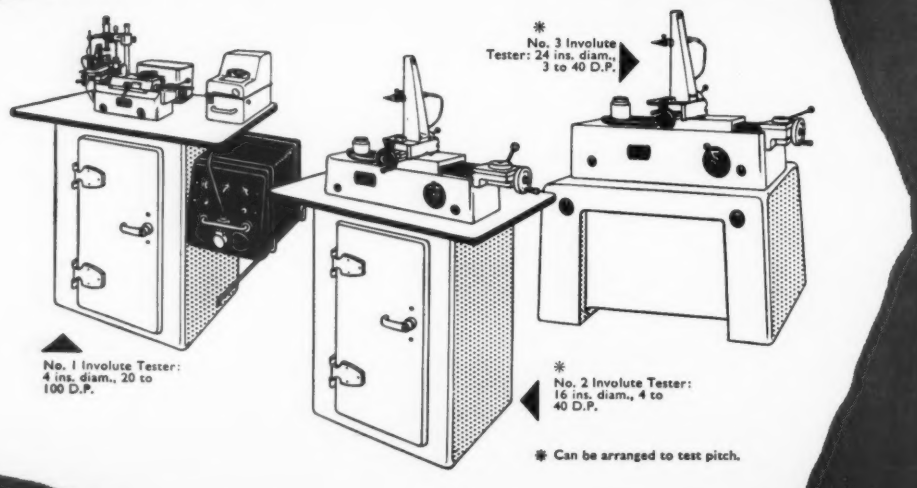
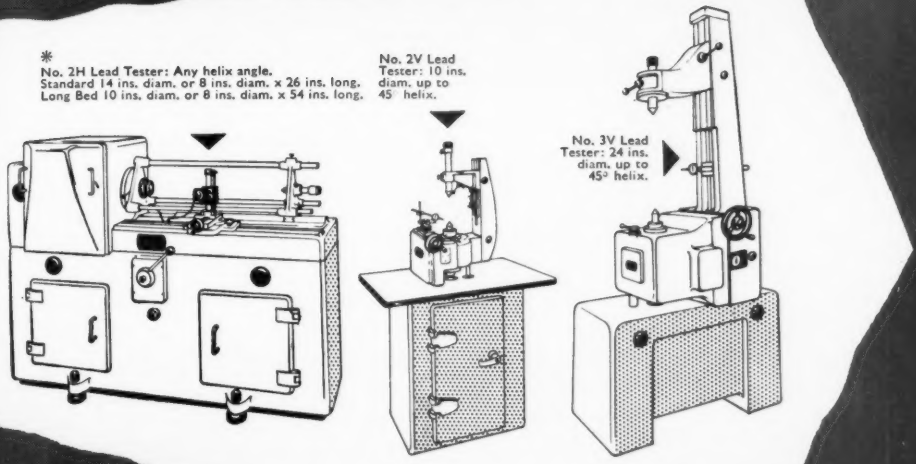
* No. 3 Rolling Gear Tester: 24 ins. diam., 3 to 40 D.P.
* No. 2 Rolling Gear Tester: 14 ins. diam., 4 to 40 D.P.
* No. 4 Rolling Gear Tester: 48 ins. diam., 2 to 16 D.P.
9" ('5') Type) Rolling Gear Tester: 14 ins. diam., 4 to 20 D.P.

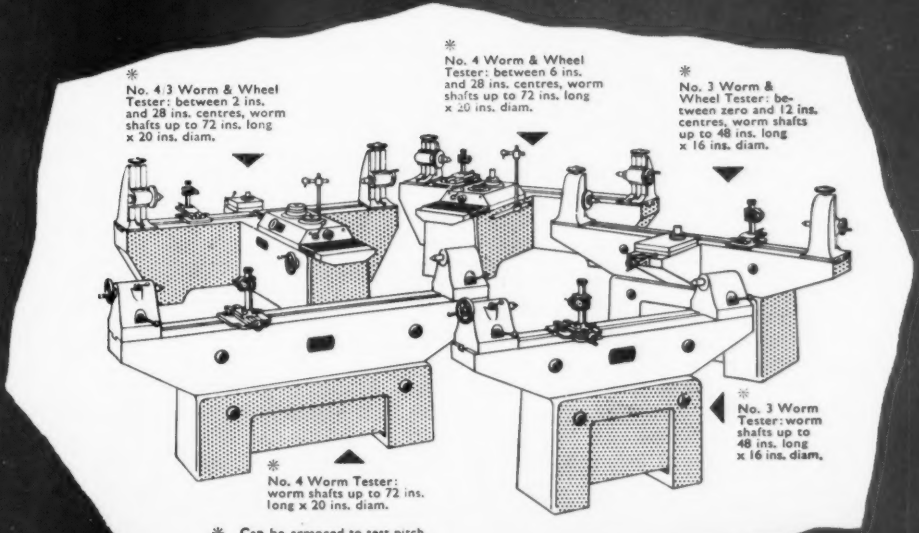

* No. 3 Involute Tester: 24 ins. diam., 3 to 40 D.P.
No. 1 Involute Tester: 4 ins. diam., 20 to 100 D.P.
* No. 2 Involute Tester: 16 ins. diam., 4 to 40 D.P.

* Can be arranged to test pitch.

ne for gear testing . . .


* No. 2H Lead Tester: Any helix angle. Standard 14 ins. diam. or 8 ins. diam. x 26 ins. long. Long Bed 10 ins. diam. or 8 ins. diam. x 54 ins. long.
No. 2V Lead Tester: 10 ins. diam. up to 45° helix.
No. 3V Lead Tester: 24 ins. diam. up to 45° helix.

From an extensive range Goulders can supply Gear Testing Instruments for any type of gear which can be instrument mounted.


* No. 4/3 Worm & Wheel Tester: between 2 ins. and 28 ins. centres, worm shafts up to 72 ins. long x 20 ins. diam.
* No. 4 Worm & Wheel Tester: between 6 ins. and 28 ins. centres, worm shafts up to 72 ins. long x 20 ins. diam.
* No. 3 Worm & Wheel Tester: between zero and 12 ins. centres, worm shafts up to 48 ins. long x 16 ins. diam.
* No. 3 Worm Tester: worm shafts up to 48 ins. long x 16 ins. diam.
* No. 4 Worm Tester: worm shafts up to 72 ins. long x 20 ins. diam.

* Can be arranged to test pitch

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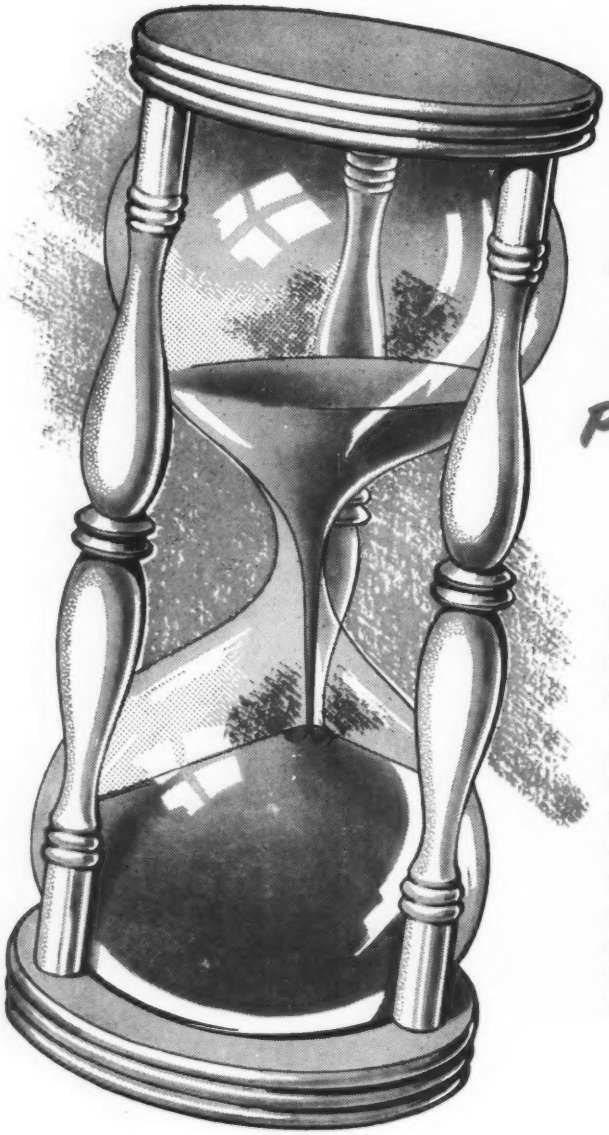

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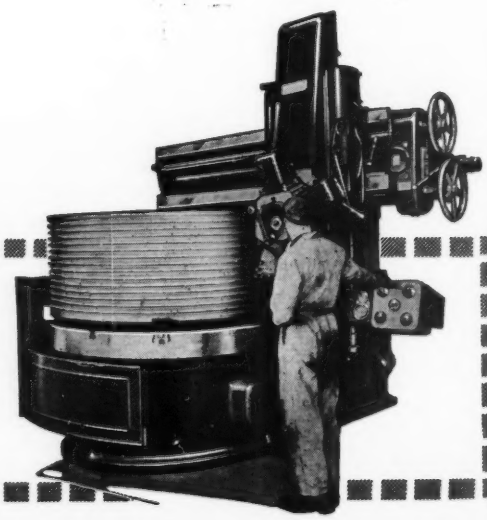

The illustration shows a Webster and Bennett 60″ Boring and Turning Mill at the Bradford Works of Crofts (Engineers) Ltd., machining a 60″ diameter vee groove pulley with a face width of 26″ having 18 grooves 1¼″ wide by 1¼″ deep.

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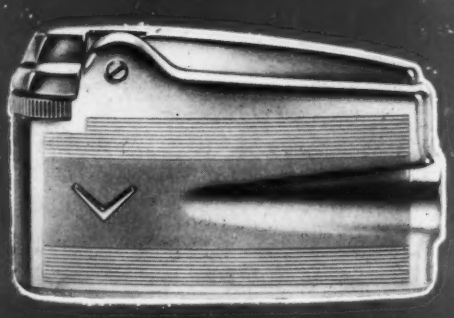

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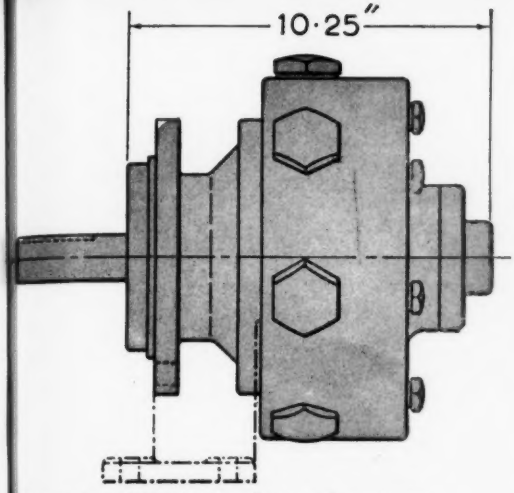

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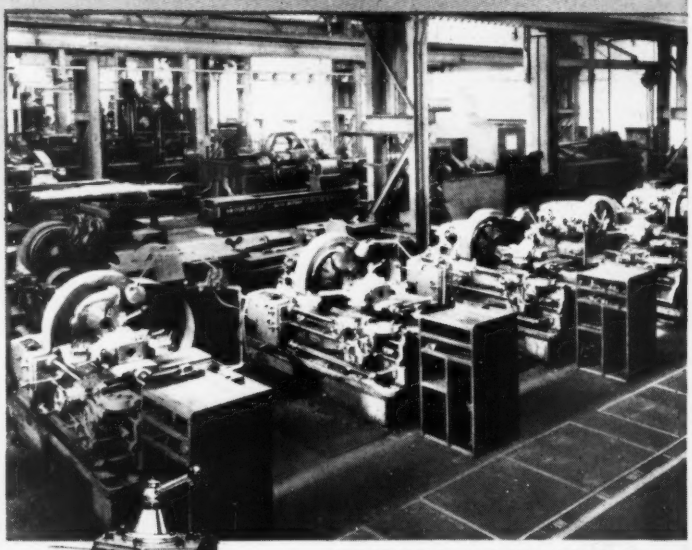
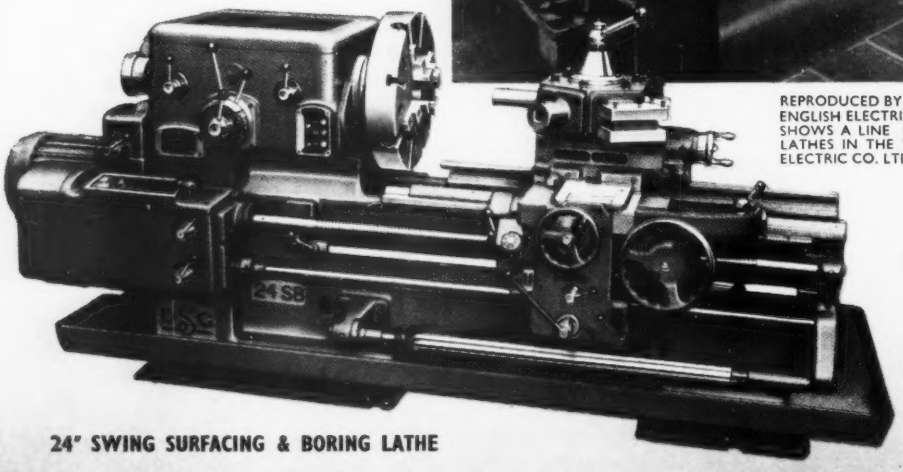


REPRODUCED BY KIND PERMISSION OF THE ENGLISH ELECTRIC CO. LTD. ILLUSTRATION SHOWS A LINE OF SURFACING & BORING LATHES IN THE WORKS OF THE ENGLISH ELECTRIC CO. LTD. BRADFORD



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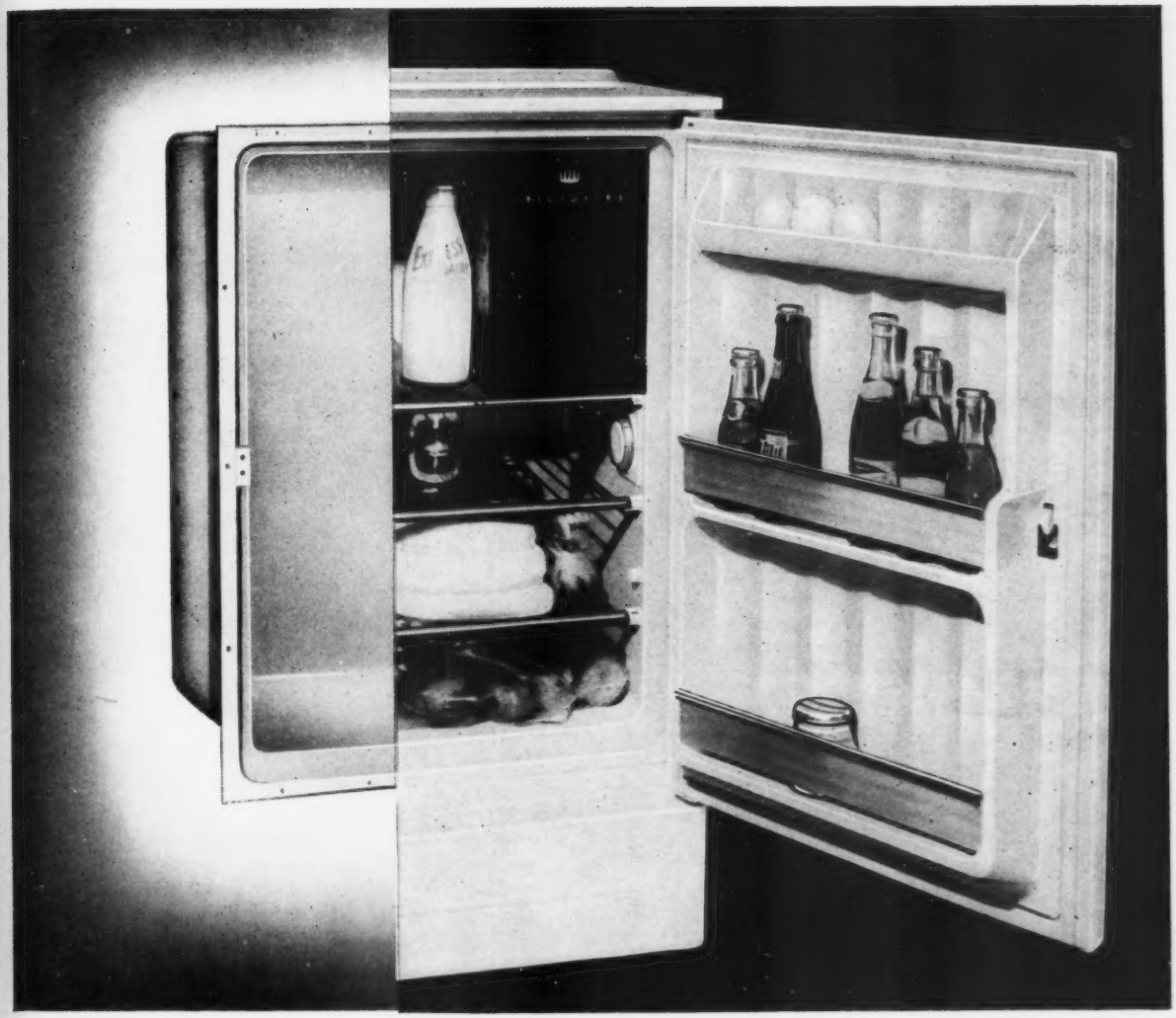
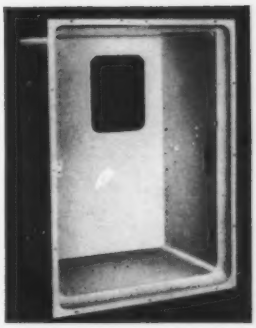


PLASTICS

The liners of modern refrigerators are moulded complete in one operation in high impact polystyrene. The injection moulding machines used in these operations are, it is claimed, the biggest built in the United Kingdom, and employ Vickers-Armstrongs "VSG" variable delivery pumps. Developments in the Plastics Industry continue at an ever increasing tempo, with new methods and machinery continuously being evolved to improve manufacturing standards and to increase the scope of moulding techniques. The use of these pumps in this highly specialised industry is a further example of the many and varied applications of "VSG" equipment which have been serving modern industry for over fifty years.



Moulded for Frigidaire by Ekco Plastics on Windsor AP335 machine.

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Clean the air supply of rust, dirt and moisture. Sintered bronze filter unit, whirling action baffle plate and bowl, easily cleaned without disturbing piping.

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Reduce and maintain line pressures to the actual requirementsat any point. Outstanding for higher capacity, faster response and lower pressure drop under loading.

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Here is a Machine Vice with built-in precision. As its name implies, it actually grips the work hard down on to its table or parallels. An accurate set-up in seconds !

The illustrations show the boring of a location pin hole in a fuel pump assembly fixture at the premises of Messrs. AC-Delco, Liverpool, by whose courtesy the photographs are reproduced.

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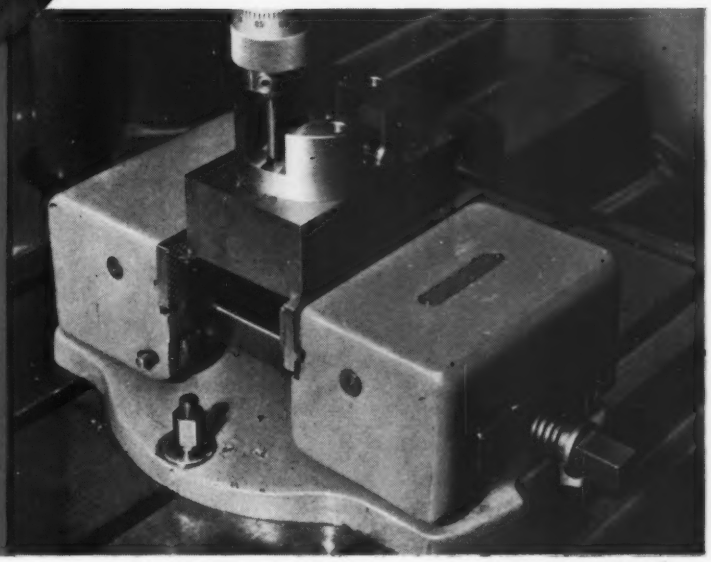
DOWN GRIP

MACHINE VICE



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The superior design of these products is the result of prolonged research and development. They are far in advance of similar tools of comparable price and much faster speeds and feeds are achieved with the cutters.

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The large Compressor illustrated is typical of our 'Comoblok' range of machines. This range covers capacities from 500—2,000 c.f.m. These machines are of the double-acting crosshead type, and are suitable for pressures up to 50 p.s.i.g. single stage, and 150 p.s.i.g. two stage. They are remarkable for their low power consumption and compact design. Send for Leaflet No. T29.

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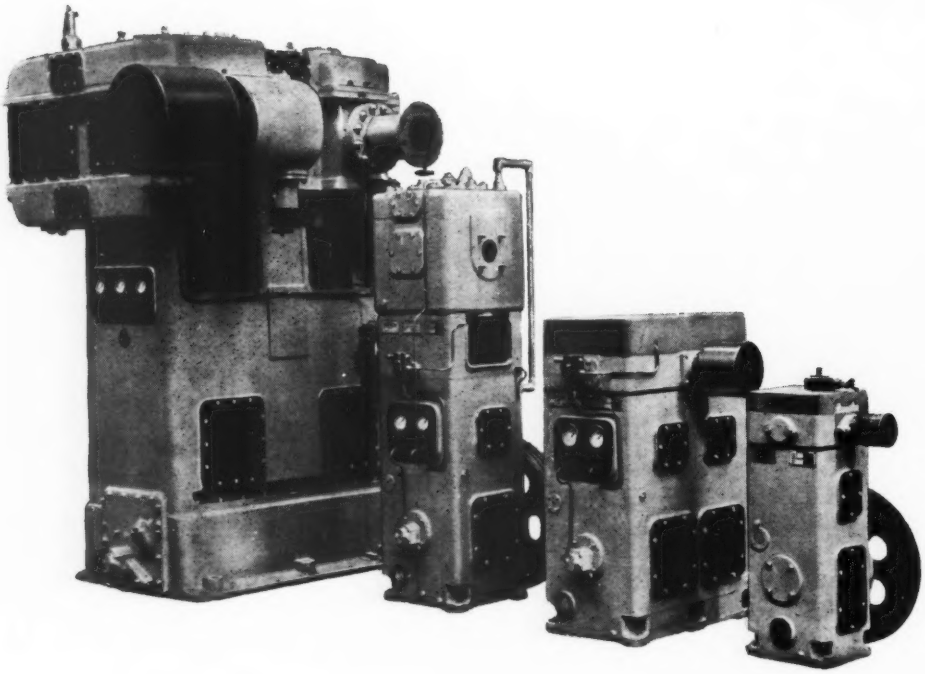

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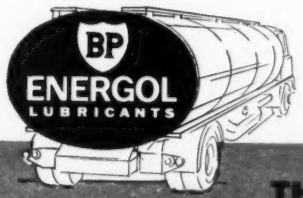

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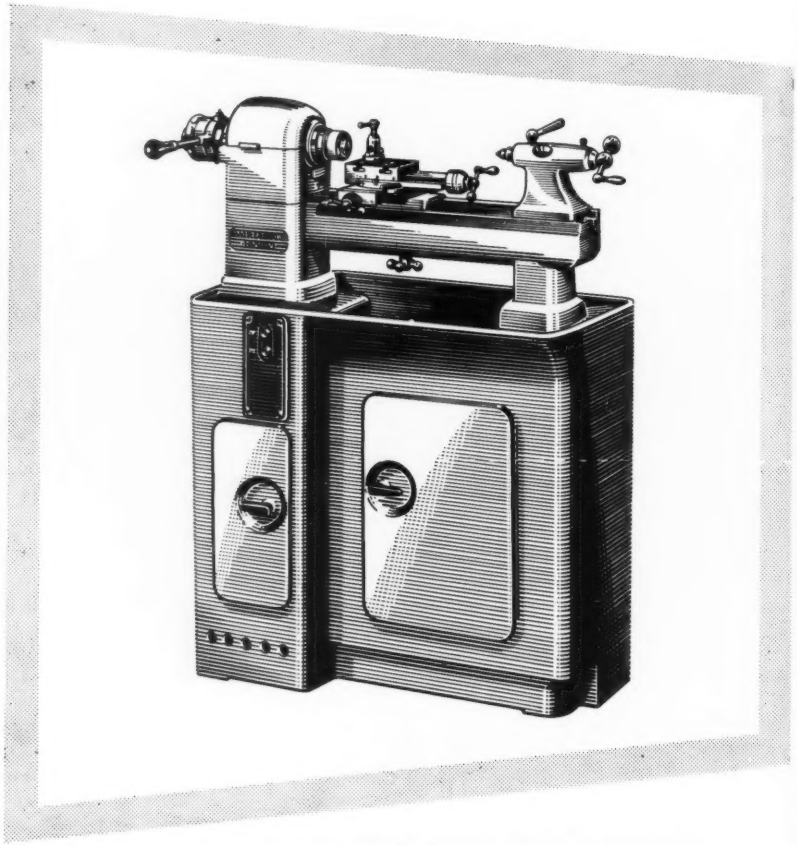

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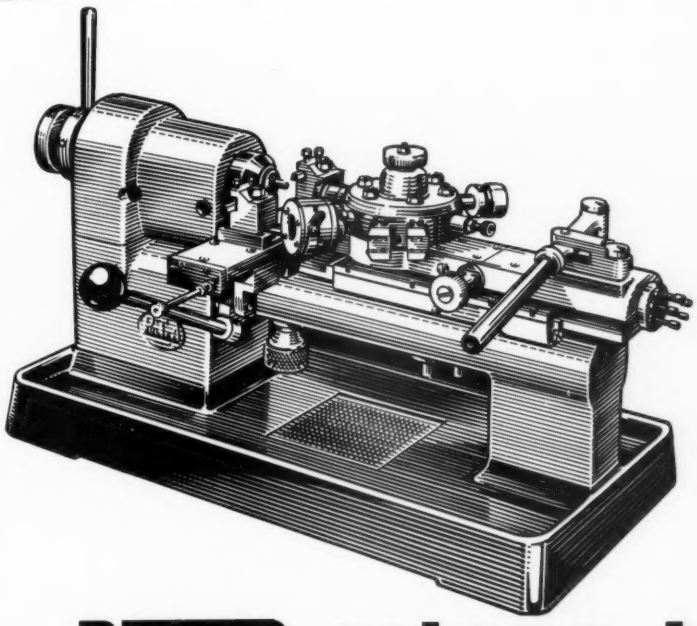

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The Pultra Capstan Lathe illustrated is available in 50, 70 and 90mm. centre heights and can also be supplied as Toolroom, General Purpose and Production models.
Lathes can be equipped to your requirements from the standard units.

(machine tools) Ltd.

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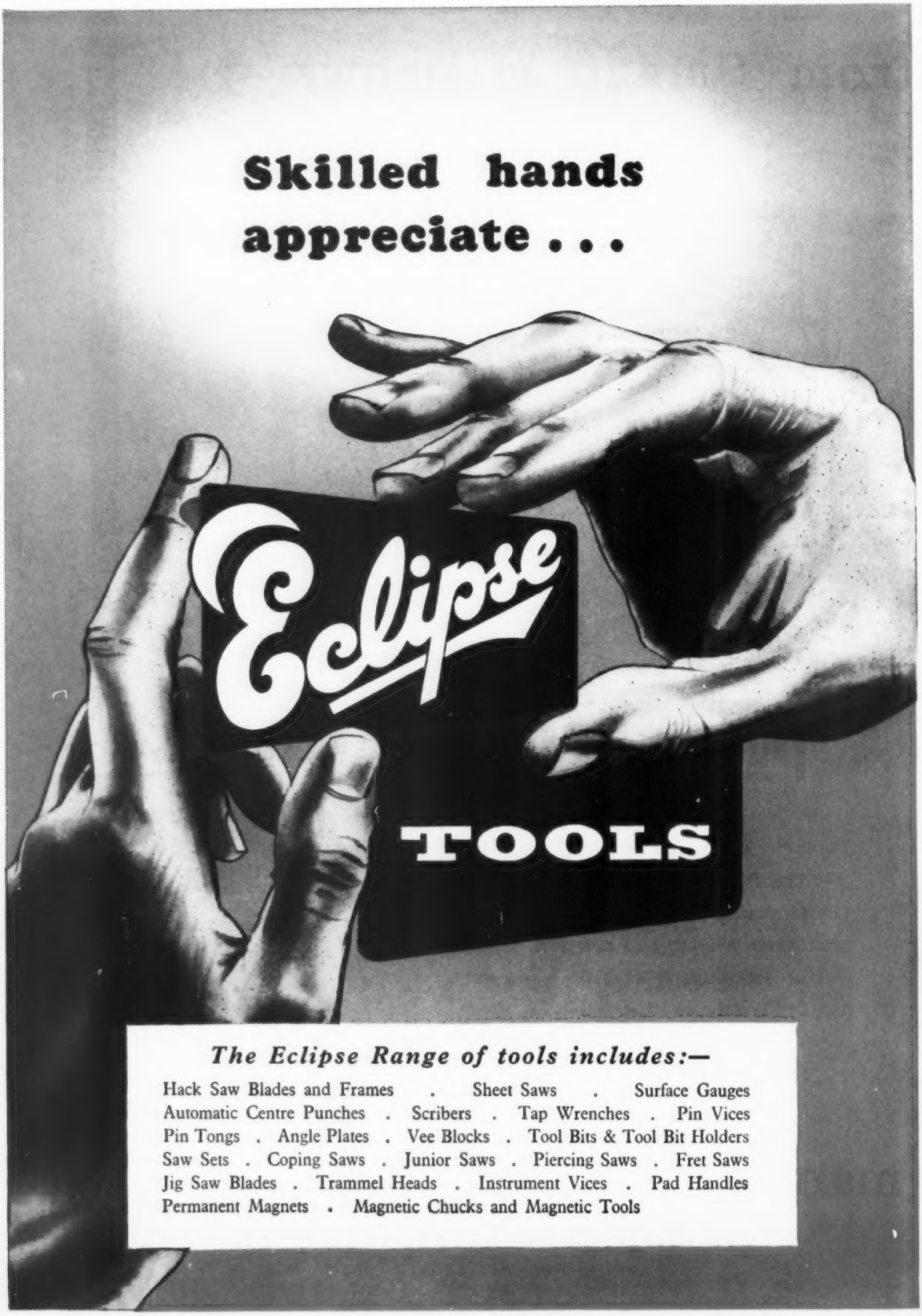

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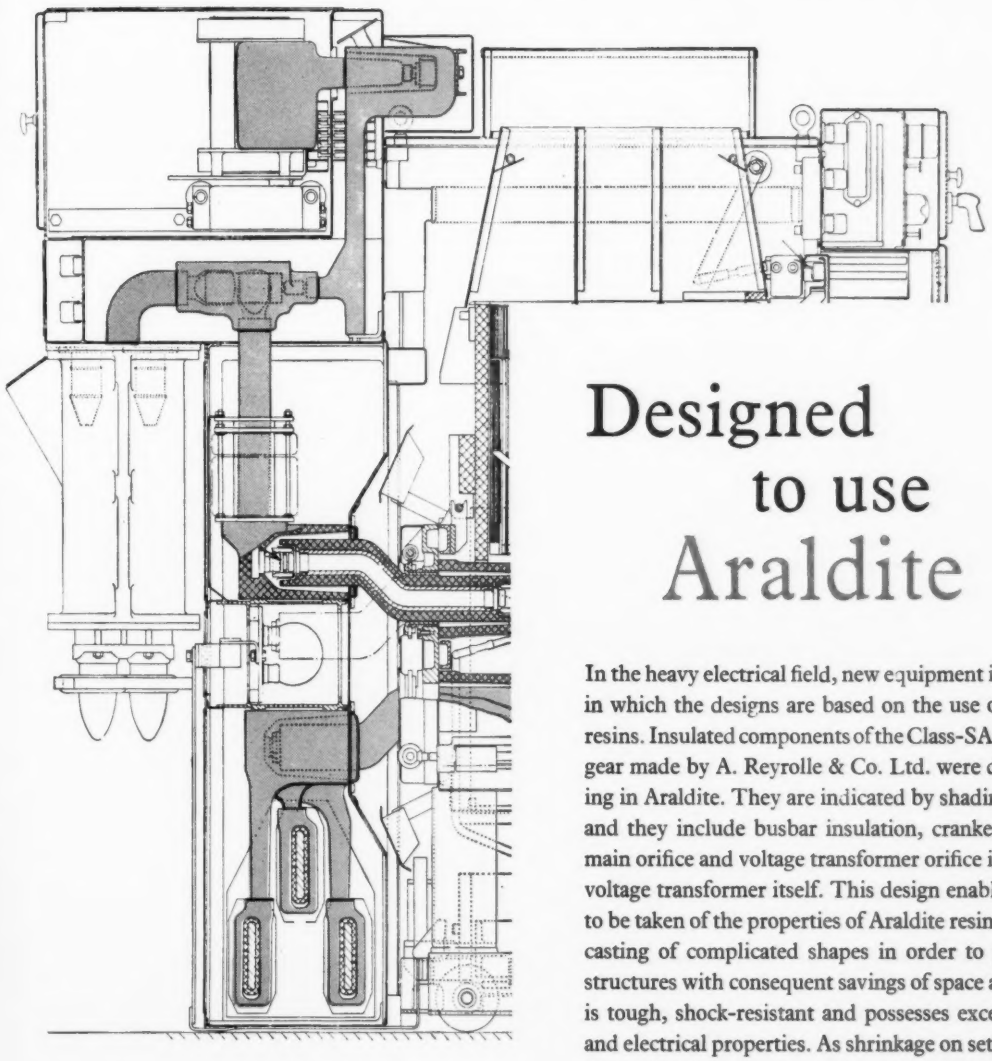

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In the heavy electrical field, new equipment is being produced in which the designs are based on the use of Araldite epoxy resins. Insulated components of the Class-SA air-break switchgear made by A. Reyrolle & Co. Ltd. were designed for casting in Araldite. They are indicated by shading in the diagram and they include busbar insulation, cranked plug insulator, main orifice and voltage transformer orifice insulators and the voltage transformer itself. This design enables full advantage to be taken of the properties of Araldite resins which allow the casting of complicated shapes in order to provide compact structures with consequent savings of space and cost. Araldite is tough, shock-resistant and possesses excellent mechanical and electrical properties. As shrinkage on setting is negligible, dimensional accuracy can be maintained within very close limits. Remarkable adhesion to metals makes Araldite particularly suitable for composite structures.

Insulated components of 11,000V Class-SA 500 MVA air-break switchgear by A. Reyrolle & Co. Ltd., cast in Araldite.

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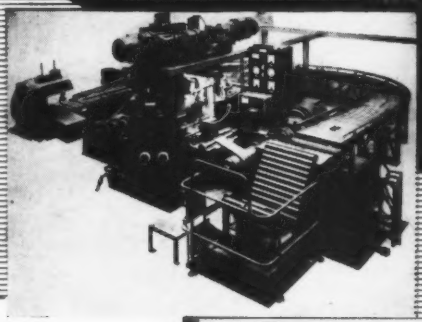
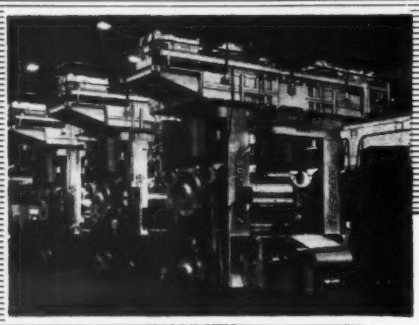


Cold our-high non-reversing mill for rolling thin brass, and copper strip up to 13in. wide. *Photograph by courtesy of D. F. Tayler & Co. Ltd., Birmingham.*

Entry-side of reversing two-high hot breaking down mill for aluminium and alloys. *Photograph by courtesy of Société Industrielle de l'Aluminium, Duffel, Belgium.*



A Three Stand Tandem Train for cold rolling aluminium and light alloy strip down to finished gauges and up to 54 in. wide.

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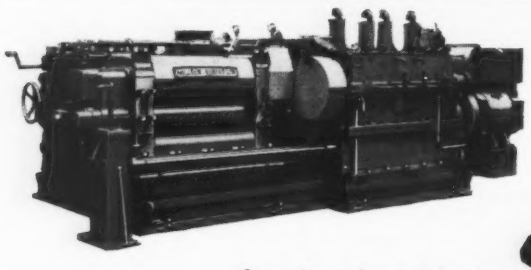
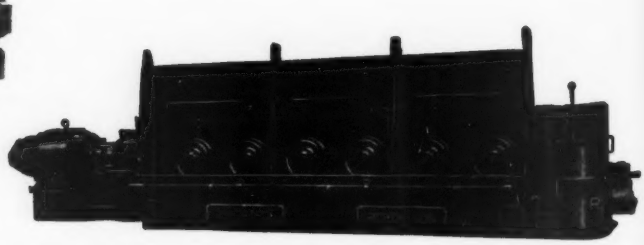
AUXILIARY EQUIPMENT and WIRE DRAWING MACHINES



Hallden-Robertson Rotary Tinplate Shear No. 45F for producing sheets up to a rate of 428 per minute.



Seven die tandem rod drawing machine for copper and copper alloy rods.

W. H. A. ROBERTSON & CO. LTD. BEDFORD, ENGLAND

LICENSEES FOR THE BUILDING OF SENDZIMIR COLD REDUCTION MILLS AND PLANETARY HOT MILLS, HALLDEN GUILLOTINE AND ROTARY FLYING SHEAR MACHINES, AND TORRINGTON METAL WORKING MACHINERY. WT. 324 WR

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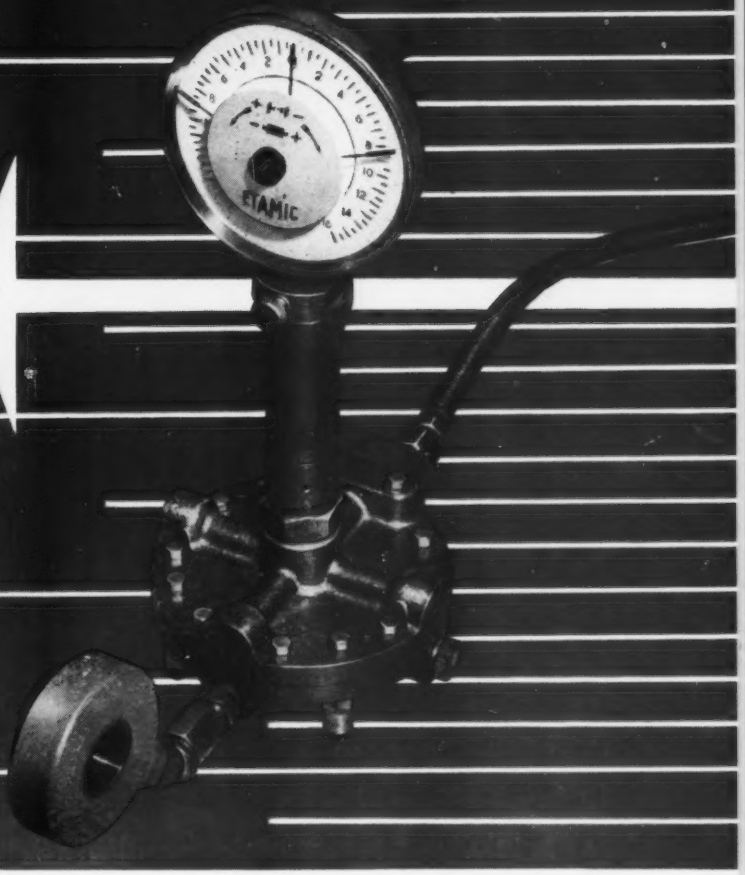
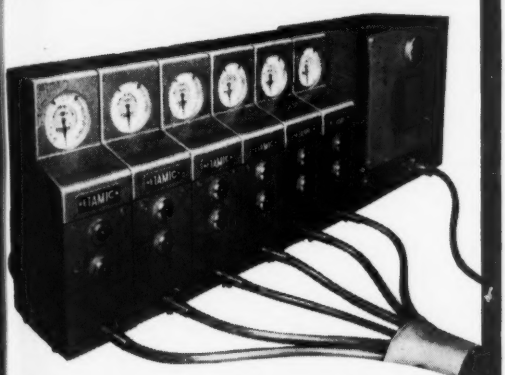
AIR GAUGING EQUIPMENT





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Embodying the true pneumatic Wheatstone Bridge principle with no mechanical or electronic amplifying systems, no pressure gauges or regulators.

SIMPLE TO USE
Direct gauge readings or observation of pre-set tolerance zone to expedite quantity gauging of external or internal diameters.

UNEXCELLED ACCURACY
Over wide measuring ranges OMT—ETAMIC air comparators have a gauging accuracy from 0.00005" to 0.00000625".

MULTI-GAUGING SYSTEMS
Complete multi-gauging systems with or without automatic feeding, acceptance and rejection mechanisms devised to customer requirement. Illustration on the left shows a compact gauging assembly for simultaneous checking of six piston diameters.

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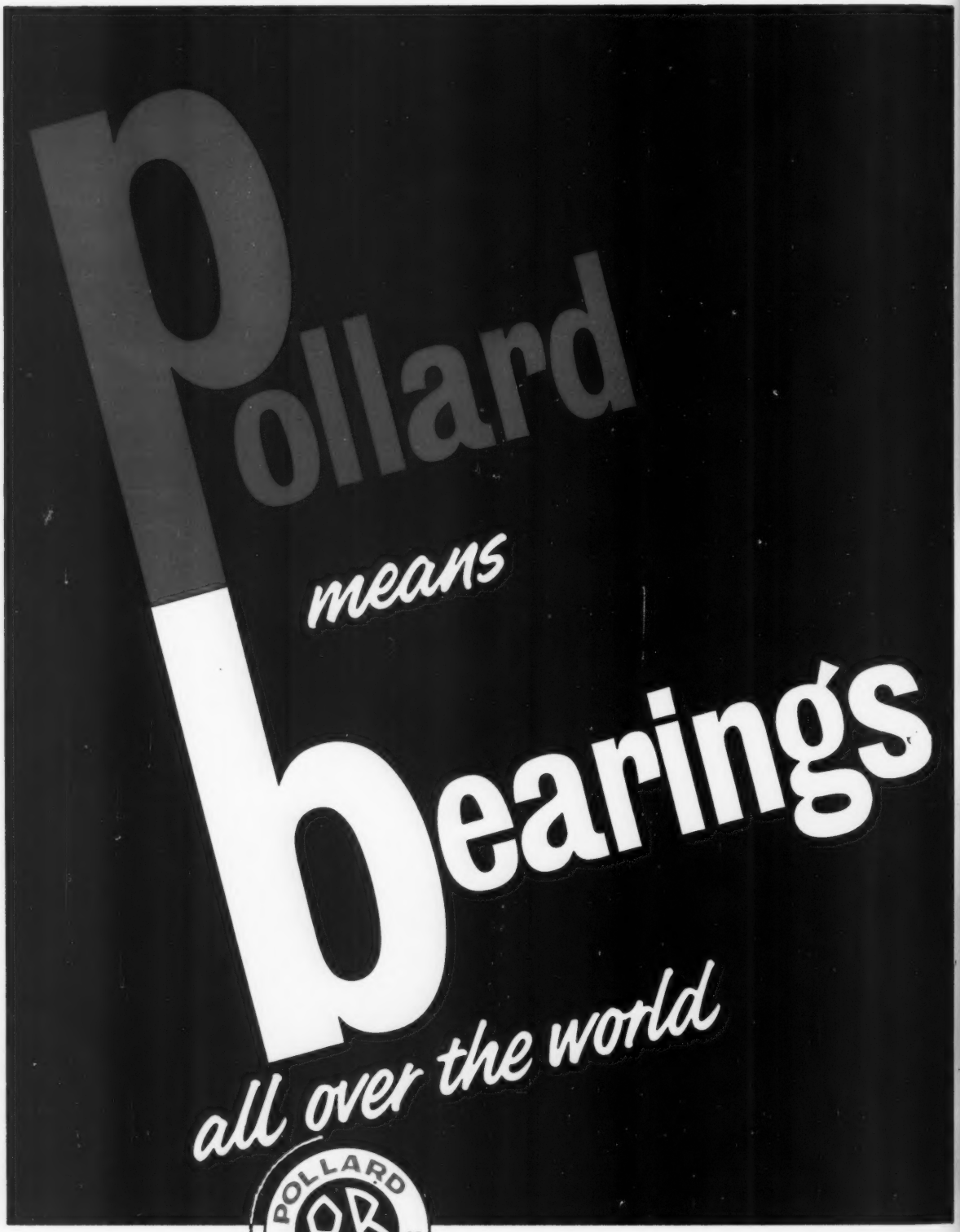

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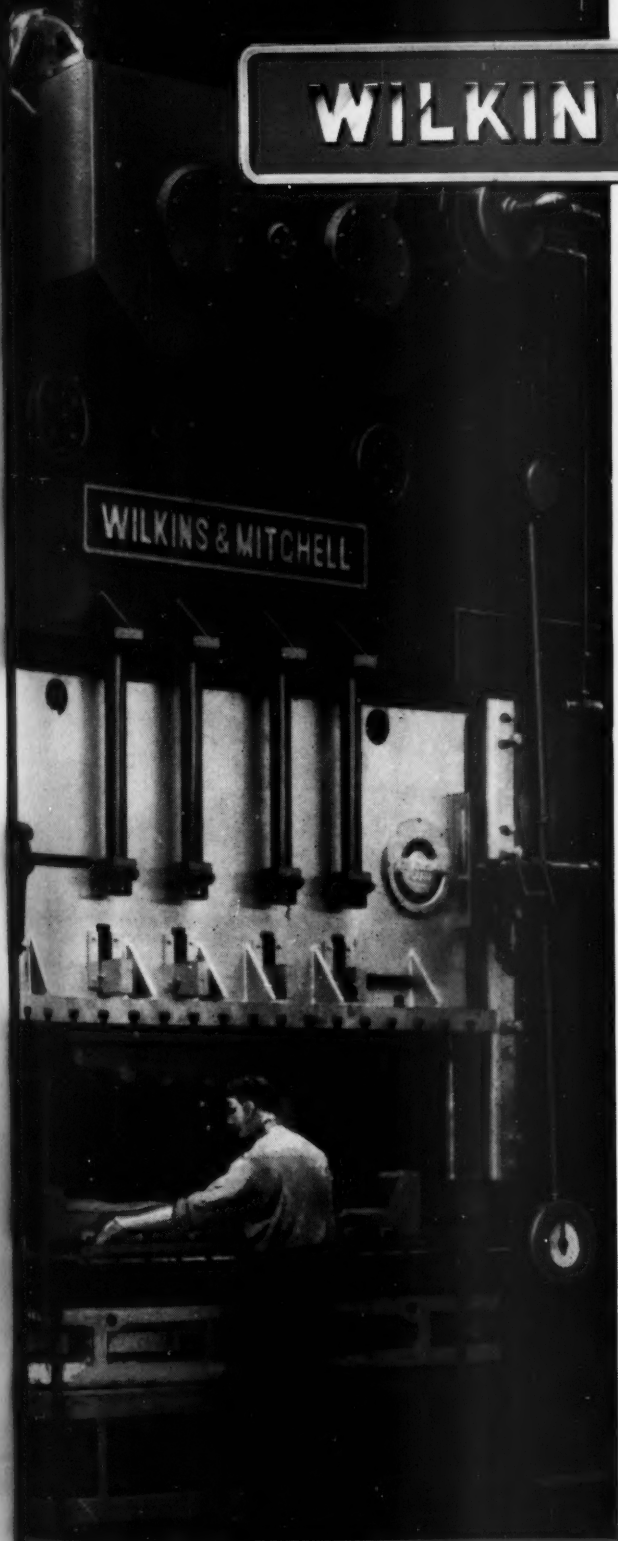

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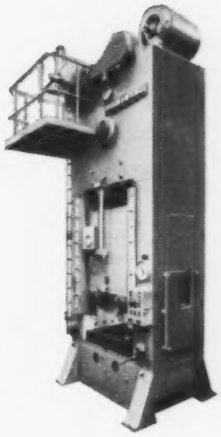
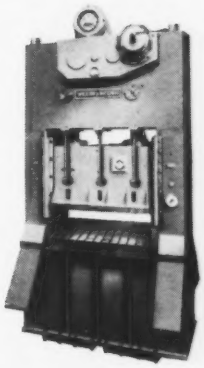


These many exclusive features that are essential for greater productivity are embodied in this range of Wilkins & Mitchell Power Presses — the presses that cut costs.



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PLEASE SEND FOR THE 'T.R.' BOOK OF THE 'PRESSES THAT CUT COSTS.'

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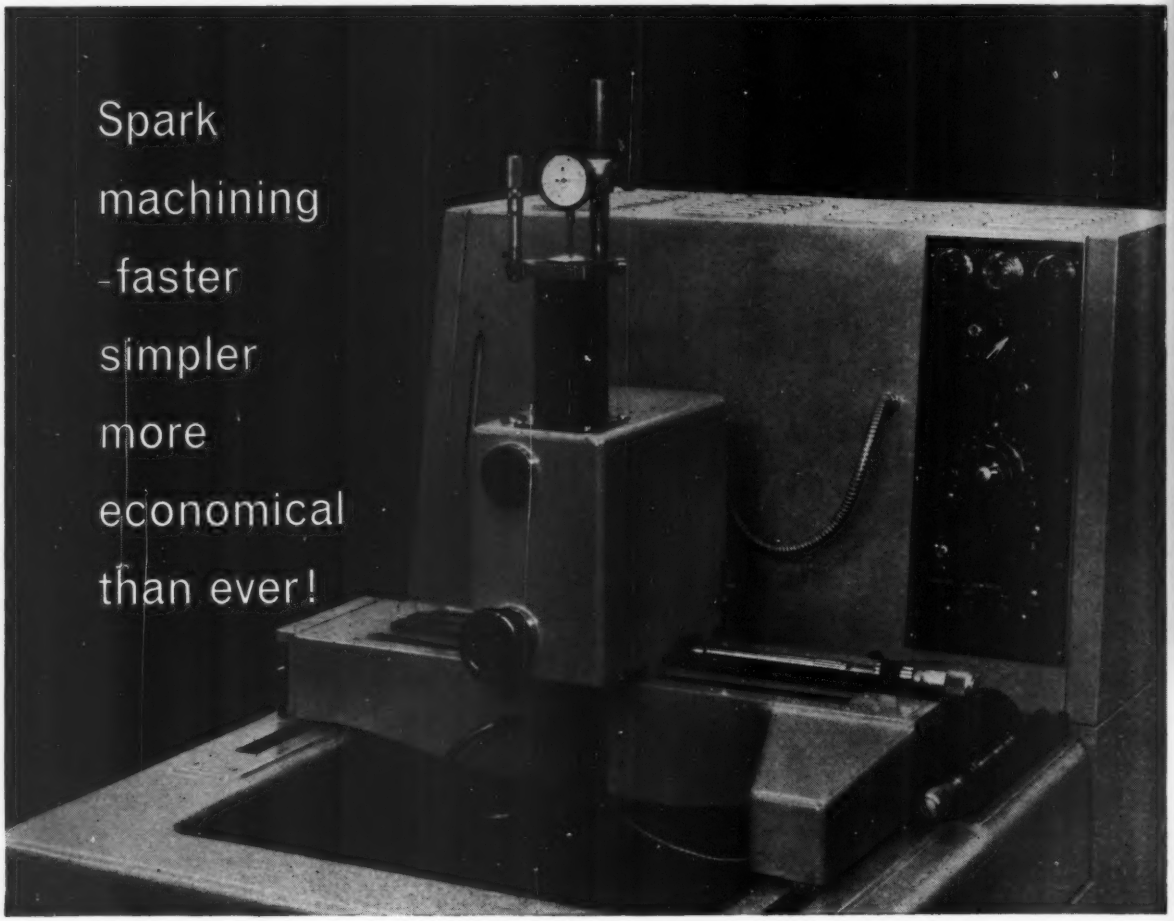

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The GKN Spark Machine (Models B1 and B2) gives higher cutting rates, greater accuracy, and—on the B2 machine—a wider range of surface finishes than ever before.

It has all these outstanding features

Both models have a co-ordinate slide movement for rapid electrode positioning; an accurate depth stop; a dial gauge to show forward movement; an alternative work-table for extra paraffin depth.

It is compact and economical

The GKN Spark Machine is well-made, sturdy and compact. All parts of it—work head, electrical equipment and paraffin system—are mounted in the same cabinet. Yet with all these advantages, installation and running costs are low.

You should know more about it

Whether you are engaged in forging, wire-drawing or press-tool making, the GKN Spark Machine is something you should know about.

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GKN
spark machine

DESIGNED BY THE
GKN GROUP RESEARCH
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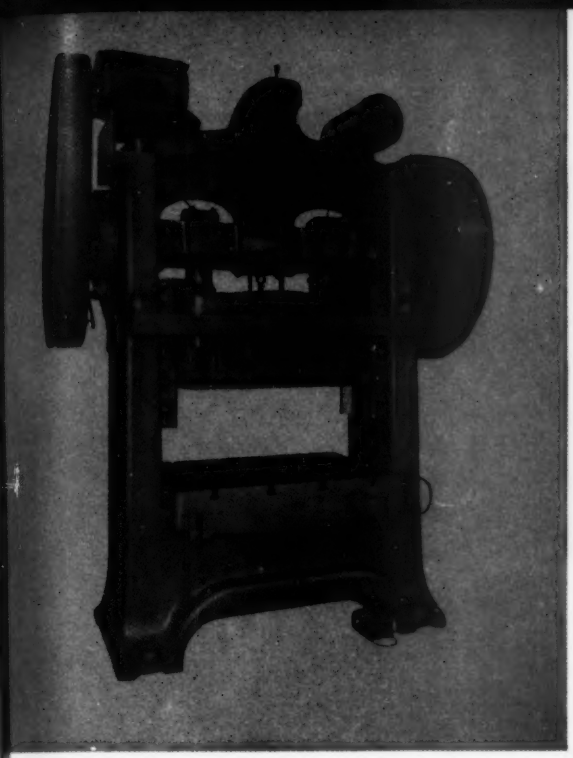

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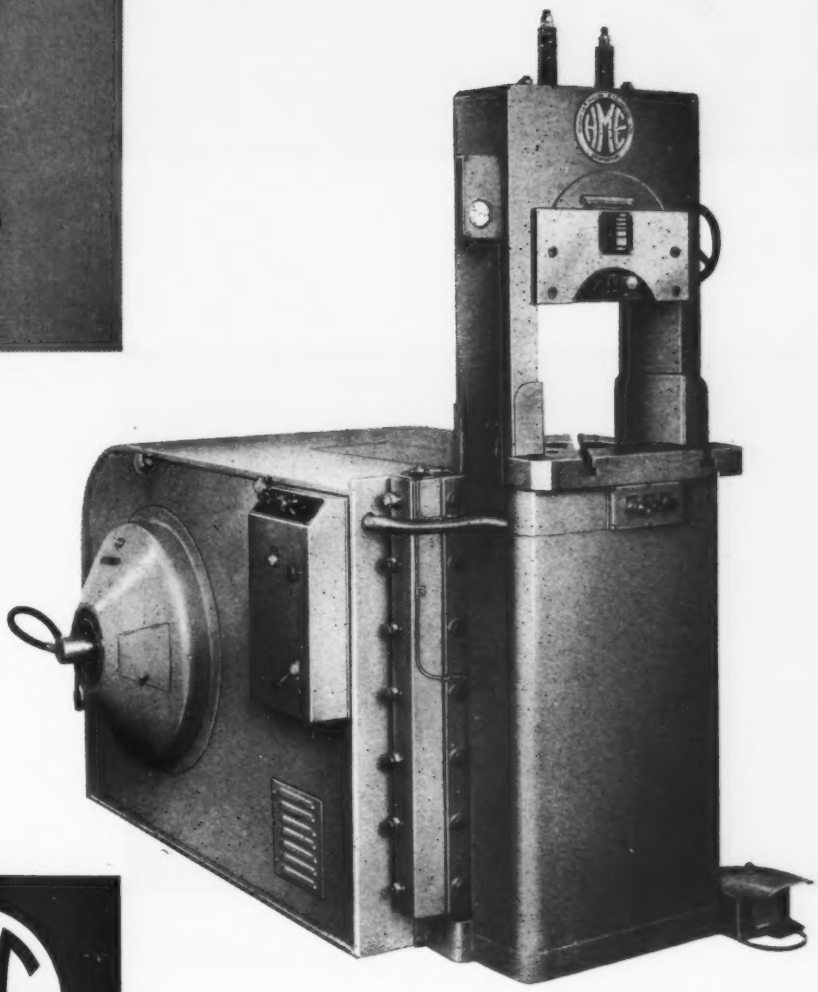

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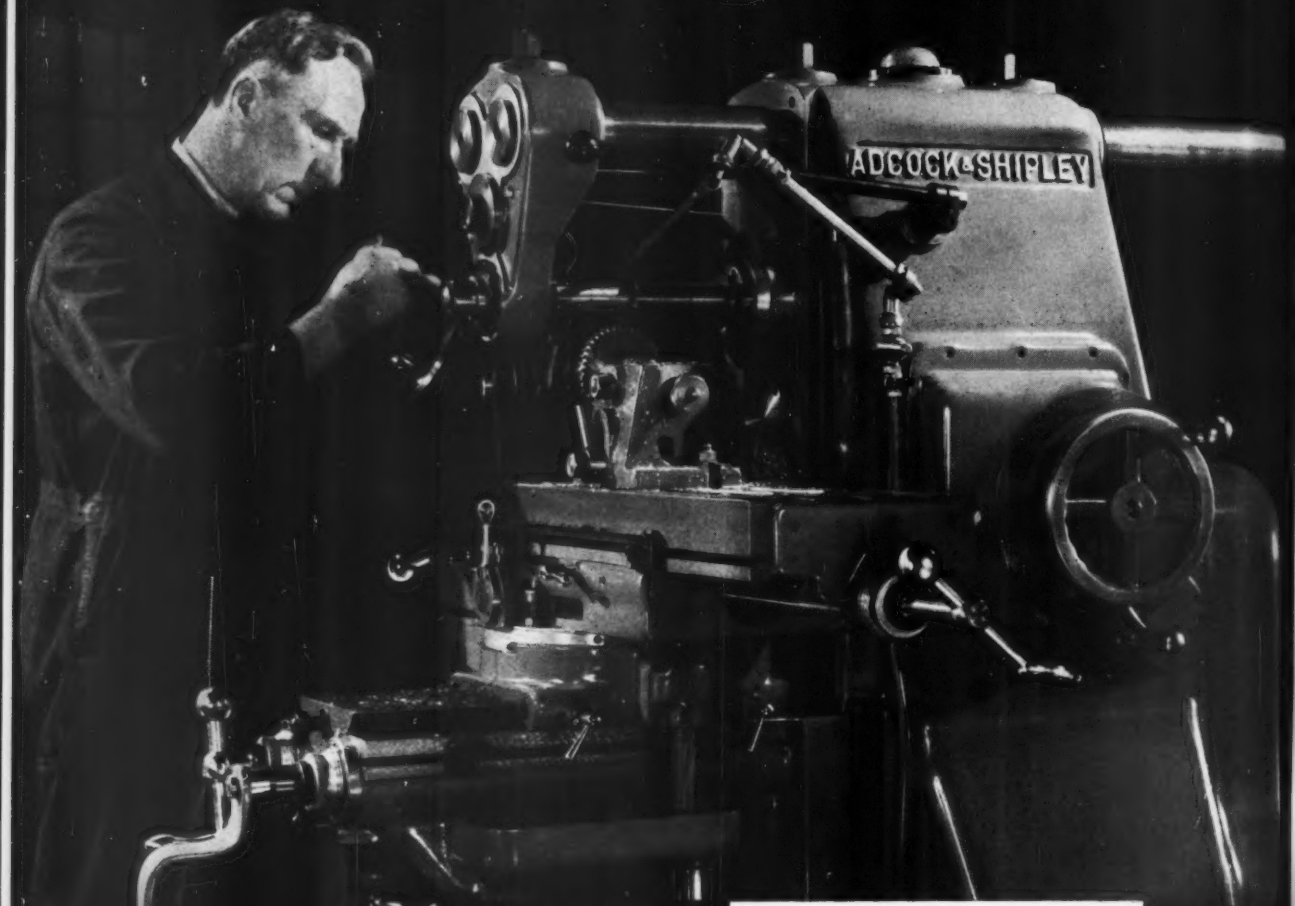
World-beating value



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MODEL

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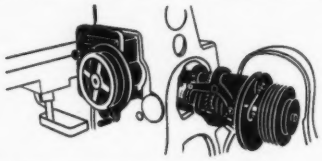
UNIVERSAL
MILLING
MACHINE

This machine represents outstanding value in universal millers, especially when you consider the high quality built into it. Ideal for tool-room use or short production runs. Unbeatable for consistent precision output with absolute minimum of maintenance or trouble. Only by omitting all unnecessary features can we produce this fine, heavily-built machine so inexpensively.



UNIT CONSTRUCTION—Maintenance is much simplified by the provision of self-contained units for the speed change mechanism and the spindle gear-box. These are flange mounted and easily withdrawn for servicing.

TABLE

Working surface 40" x 10"

Traverses—23" longitudinally—
7½" transversely—14½" vertically
Angular displacement of table—
47 degrees either side

MOTOR

Choice of single speed or two-speed 4 or 4/5 H.P.

SPEED SELECTION

Easily read dial system for rapid selection of spindle speeds:

Range A: 12 speeds from 30-600 r.p.m.
Range B: 12 speeds from 60-1200 r.p.m.
Range C: 24 speeds from 30-1200 r.p.m.
(using 2-speed motor)

FEED SELECTION

Selection and engagement by two levers. 9 feed rates, from ½" to 10" per min., or with 2-speed motor, 12 feed rates from ½" to 20" per min.

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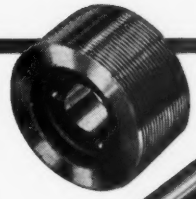
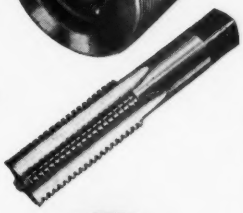
save money on parts like these



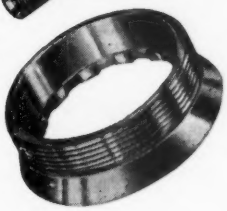
Screw Plug Gauge
2¾" dia. x 11 T.P.I. x 2¼"
Whitworth Form



High Speed Steel Tap
1" x 8 T.P.I. x 2½"
Whitworth Tap
Limits BS949
Grinding Time 80 secs.

Thread Crushing Roller
3" dia. x 8 T.P.I. x 1⅛"
American Form

Micrometer Screw
10mm.x0.5mm.x40mm.
long, S.I. Form
Grinding Time 6 mins.



Internal Combustion
Engine Valve Seat
1¾" dia. x 20 T.P.I. x ⅝"
Whitworth Form
Grinding Time 50 secs.

The various 'MATRIX' Models represent the world's widest range of Thread Grinding Machines.
They will accommodate a range of work extending from the finest threads used in precision instrument manufacture up to a maximum capacity of 14" diameter by 72" long.
The machines embody the latest advances in toolroom and production thread grinding technique and are based on many years of research and development.

Steering Worm
26mm. x 6mm. x 66 mm. long
L.H. Worm Form
Grinding Time 3 mins.

Internal Threaded Component
1½" dia. x 16 T.P.I. x ½" Unified Form
Grinding Time 4 mins.

Screw Plug Gauge
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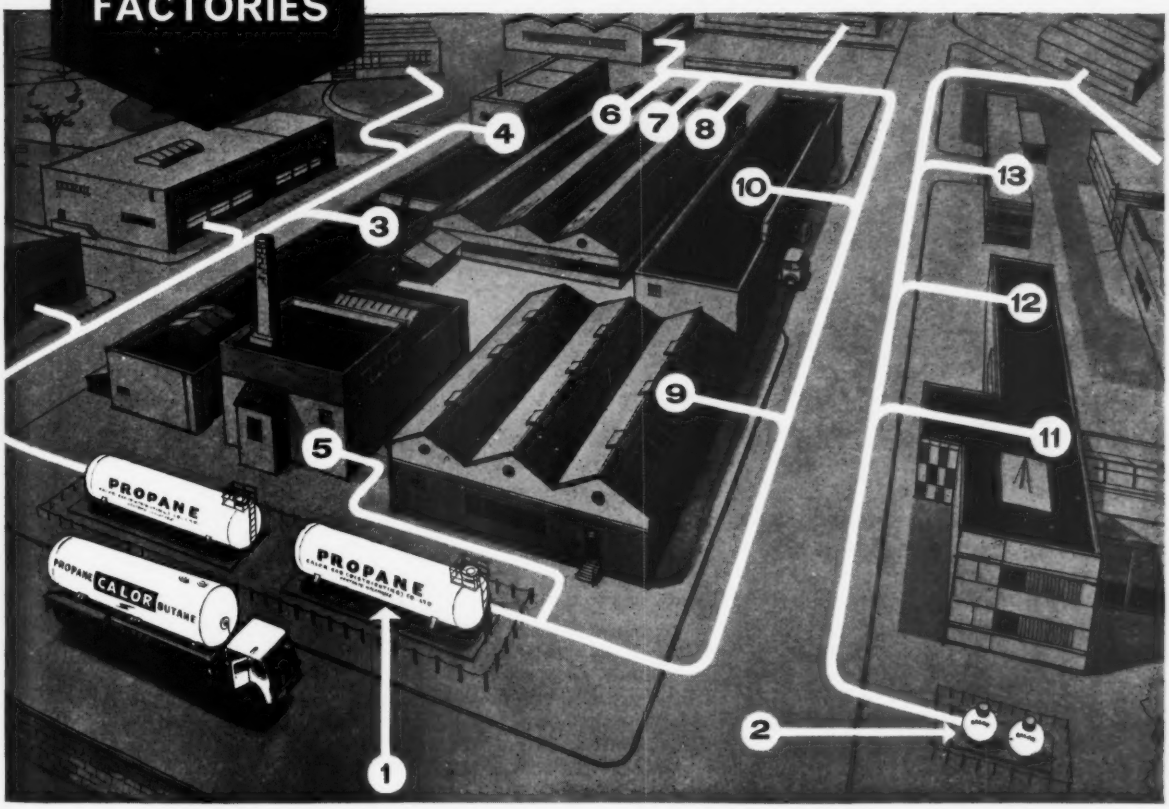

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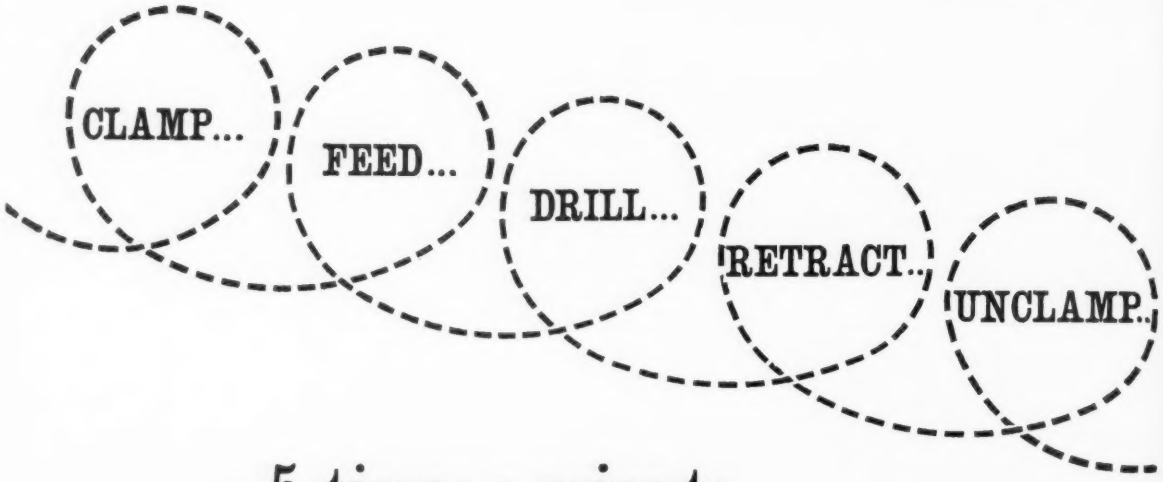

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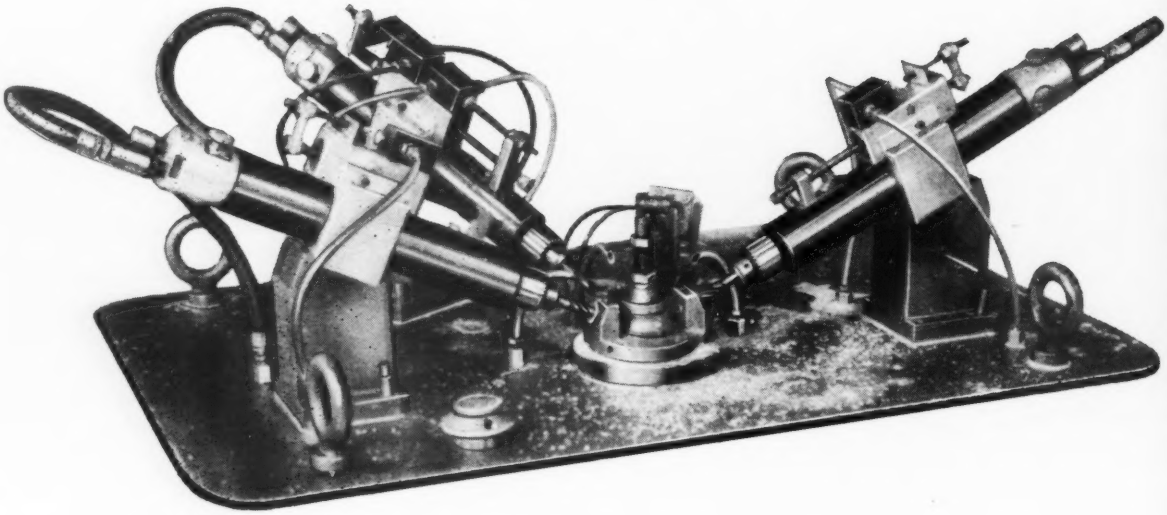

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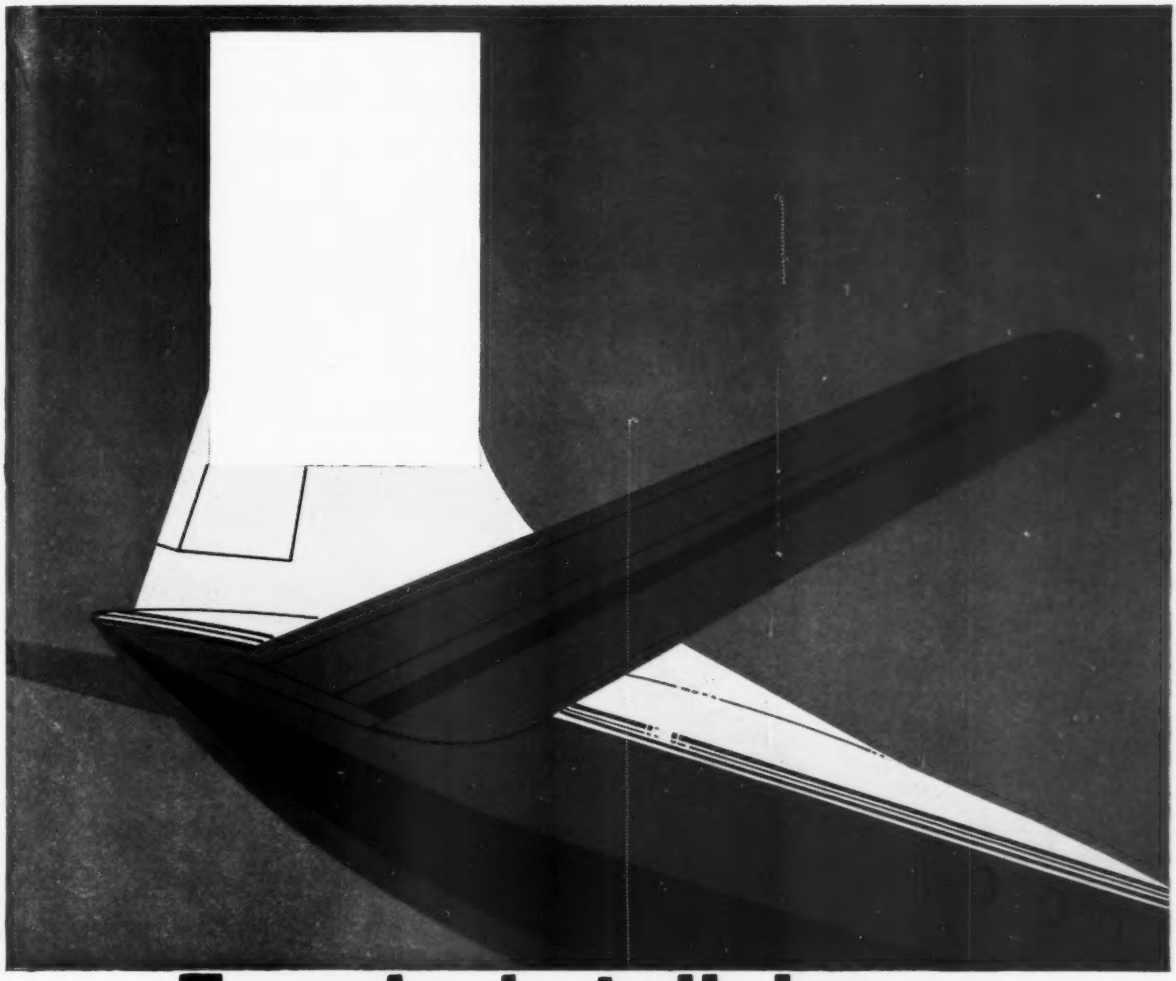
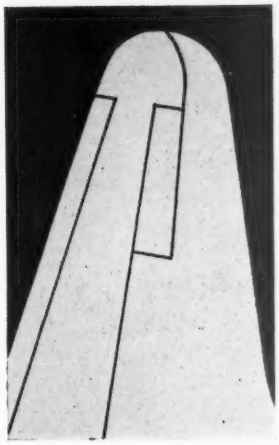


Tuesday's tailplane



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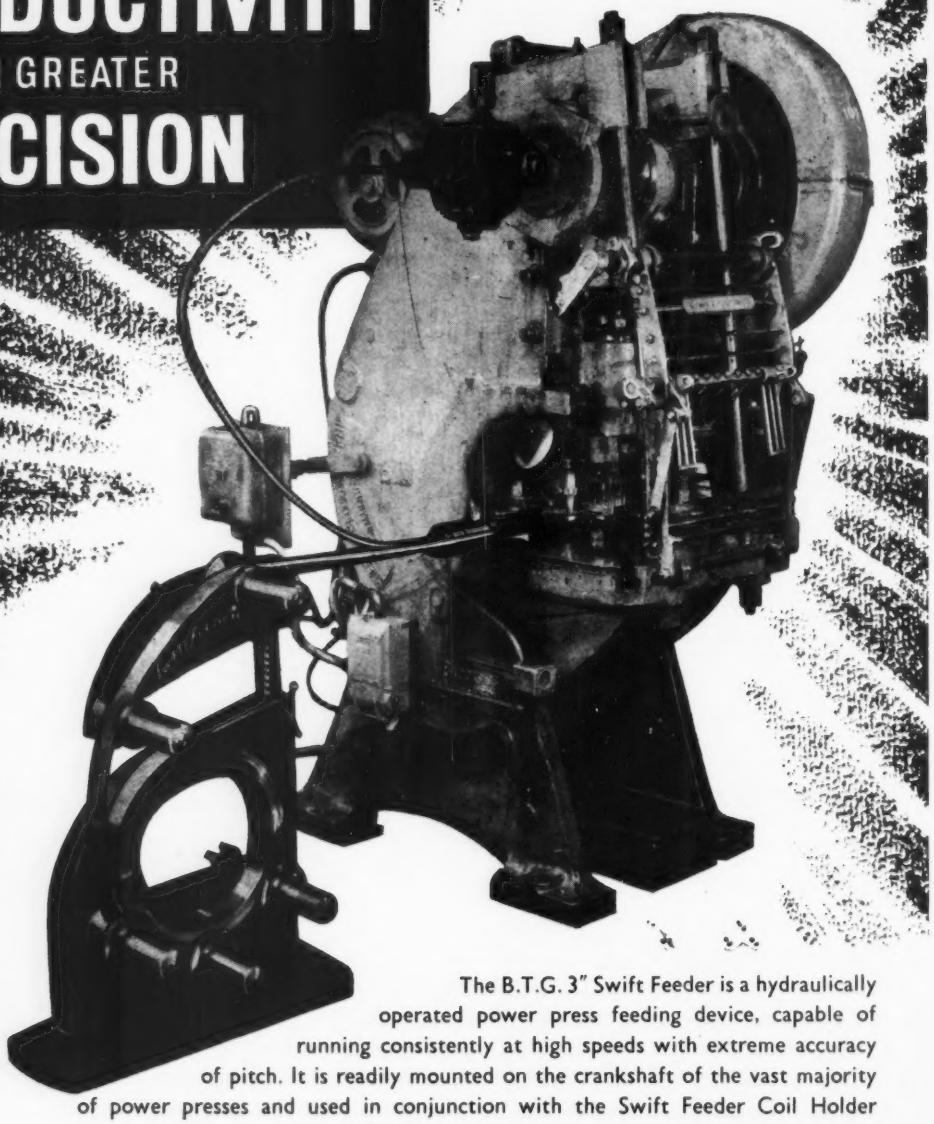

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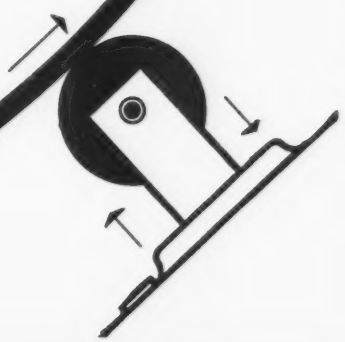

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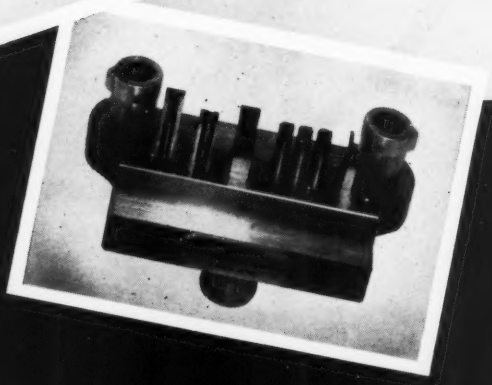

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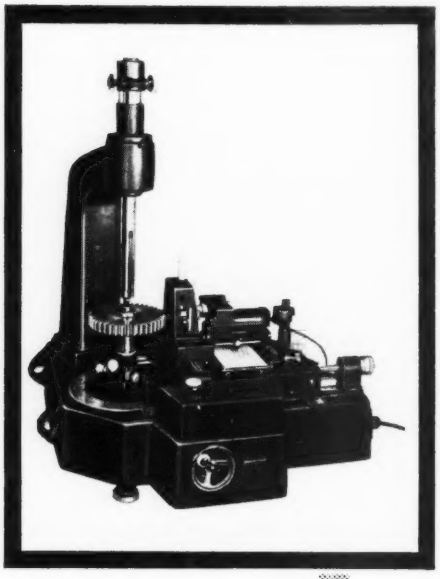

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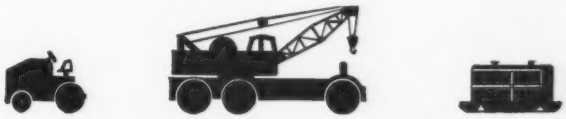

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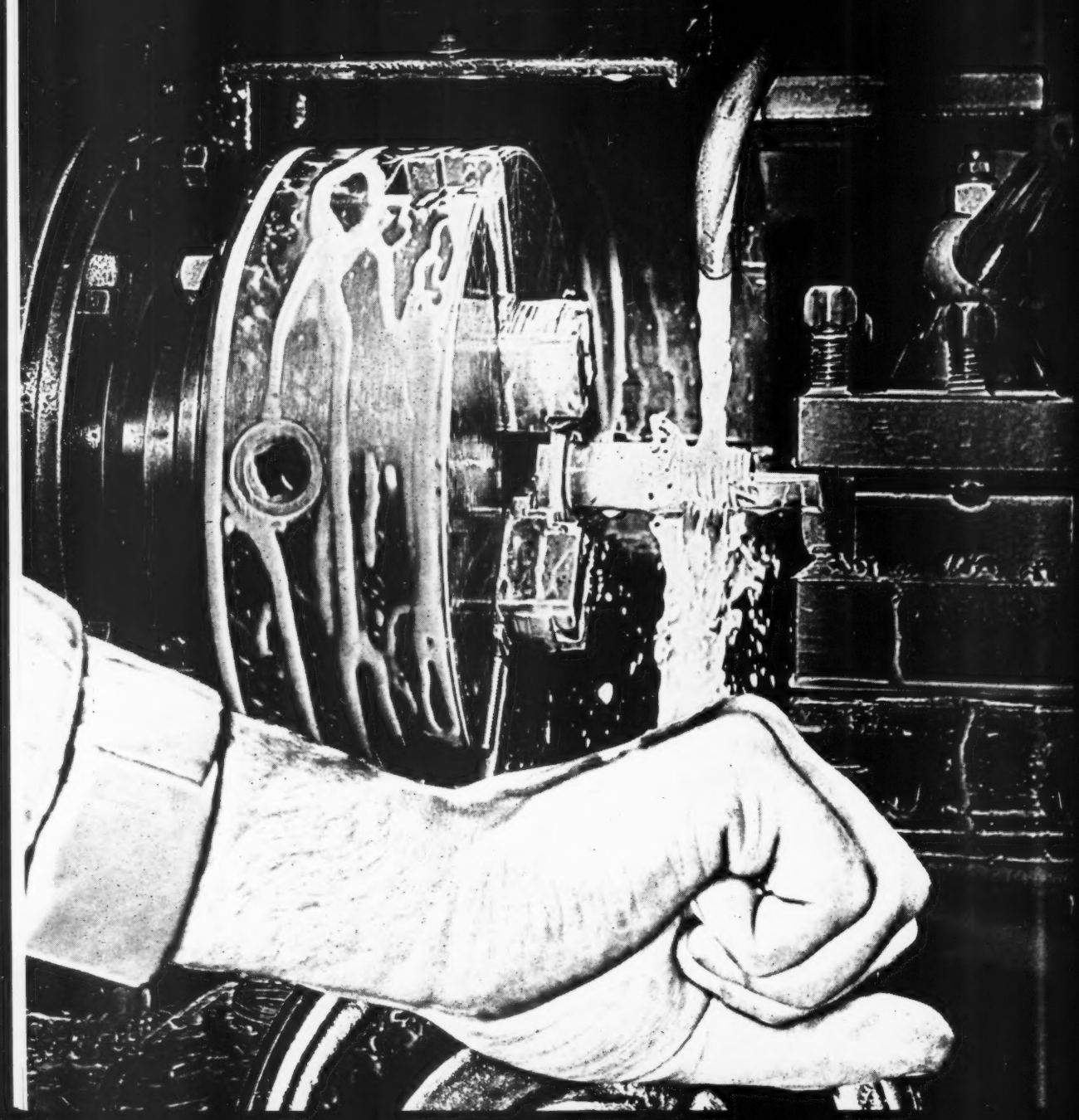

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With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

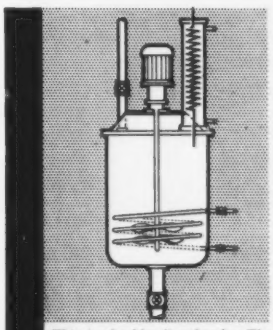
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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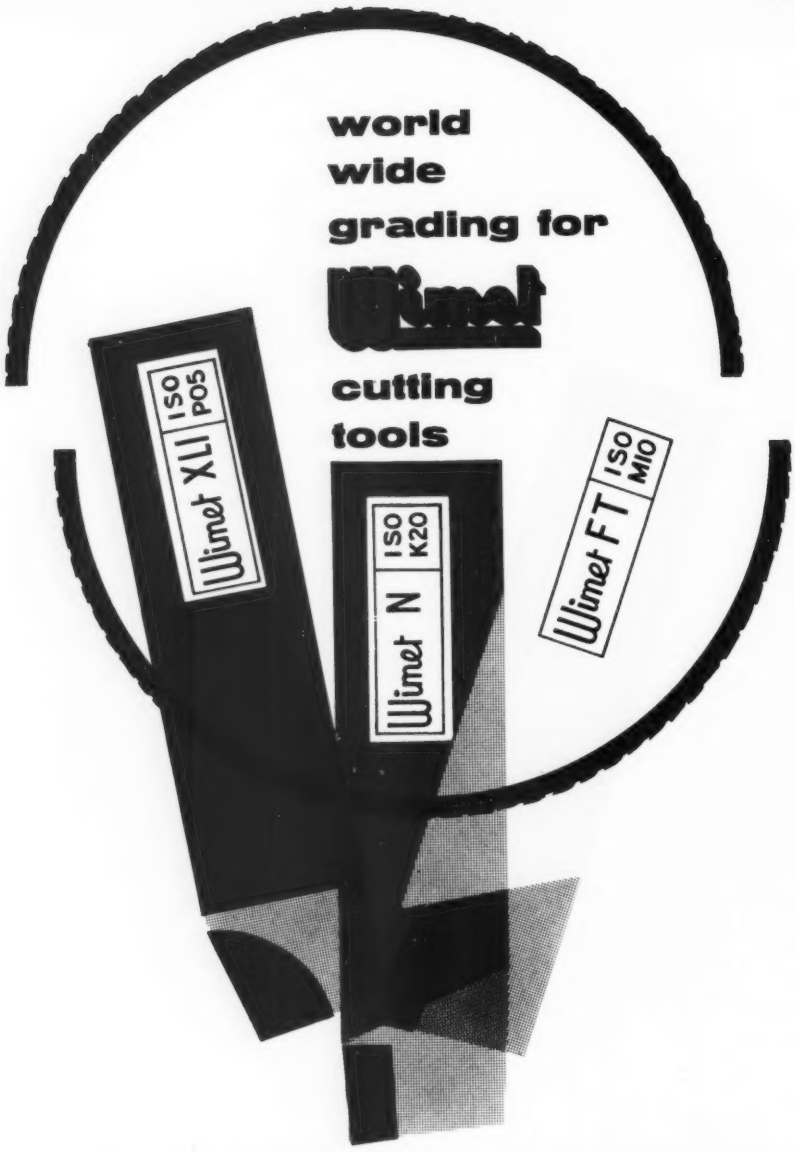
another proof of Shell leadership in lubrication



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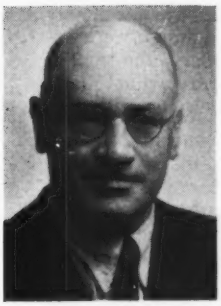
The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 No. 10 OCTOBER, 1960

MACHINE TOOL DEVELOPMENT AND NATIONAL ECONOMY

A review by Sir STANLEY RAWSON



This Paper was presented to The Institution of Production Engineers on 27th June, 1960, as The 1960 Viscount Nuffield Paper.

Sir Stanley Rawson, who recently retired as Vice-Chairman of John Brown & Company Limited, was Director-General of Machine Tools at The Ministry of Supply from 1951 to 1953.

In this Paper he gives particular emphasis to the trends for the future.

WE are living today, our astronomers tell us, in a universe that is expanding at an accelerating rate. If we look at the increase in the production in the world of raw materials, or agricultural production, and finally at the increase in world population, we find ourselves faced with the necessity not to increase the mere means of living, but to create for almost the entire world the surrounding instruments of the modern way of life. Modern means of communication, the cinema, radio and television, the spoken word and the living picture — so much more immediate and powerful in its impact than the slow process of linguistic study and the laborious effort to reason how and why — have created demands in the least complicated minds for the satisfaction of an affluent society. Where such powerful drives exist, there are only two modes by which they can be satisfied — war or economic development which is prepared to skip a century or two.

War is still a natural means of appropriating the goods and capacities of others; and because war between advanced nations may involve their mutual destruction, that does not mean that war as a policy of economic enrichment has ceased to exist. In a

very large sense this is an enquiry into what constitutes the mainspring, the *condicio sine qua non* of economic development. We take so much for granted today that we find it difficult to realise that our world, or rather the instrumental background of our world, is the creation of little more than a century. If we try to set out in summary form the conditions of this creation, we find them to be the following :

(i) the ability to handle heavy weight;
(ii) the ability to make use of the inherent strength of materials of construction;
(iii) the ability to generate and supply power;
(iv) the ability to measure and to test.

Every one of the devices in which these abilities find expression has of course a very long history. Many of them have made sudden spurts in growth and complexity under the stimulus of war; and these devices themselves inspired and conditioned the growth of the machines which embody these several abilities. They all imply striking changes in the art of metallurgy and striking changes in the understanding of the physical world and the designing and application of what are described as ingenious mechanisms. There are very few large machines existing today whose main lines of actual or possible design were not laid down many years ago; and similarly the smaller machines embody in complex forms what many engineers sought to reach with much more limited means.

definition of machine tools

You will observe that I have used the general term "machine". It is a wider term than machine tool for the machine tool is indivisible from the wider class. Many of you will recall the difficulties which arose in the definition of machine tools for the purposes of the Machine Tool Control Orders. That definition comprised every mechanical device for the forming and shaping of materials and thus included every form of rolling mill, hydraulic press, extrusion press or mechanical press or draw bench. The definition of machine tool, for the purposes of the International Standards Organisation, restricts the term "machine tool" to power driven instruments for the shaping and forming of material by the removal of metal chips, a definition which excludes wood working machinery; and, as is now becoming apparent, the several forms of synthetics, and even its application to sintered materials is in some doubt. The definition is of course only required for a limited purpose, but from the economic point of view we should take cognisance of the range of machine tools which form and shape metals and metallic substances. This is of some importance, since there tends to be quite constant interchange between the processes adopted for shaping metal. For example, the original methods by which bars were cut into complicated sections, especially of the asymmetrical type, were replaced by rolls and later by extrusion dies, and in turn, where smaller quantities were needed, by surface broaching. Numerous, too, are the methods adopted for splitting the output of draw benches and rolling mills. So that it is perhaps well to look upon any mode of, or instrument for, forming constructional material as a machine tool.

The particular method or instrument adopted is controlled by a great variety of considerations, not the least of which is the way in which the material to be handled can be made to flow. There was, for example, great diversity of practice in the drafting of rolls of metal rolling mills. In the early days of iron rolling, wrought iron was relatively soft and plastic and there was room for much divergence in the design of rolls and the art of the roll-turner was very much of a black art. It was not until Puppe in 1920 and 1921 made the first serious study of the optimum rolling pressures that the rolling of steel shapes became the subject of scientific study. The immediate result was an increase of up to 25% in the number of tons per shift which a given rolling mill could do. Not only this : the study revealed the surprising fact that practically every electrically driven rolling mill was greatly overpowered. Some of this was no doubt due to the fears on the part of rolling mill men brought up on steam of the mill stalling. A steam engine would cough and hold; but a stalled electric drive might suffer serious damage.

It is probably true to say that the power consumption of rolling mills in the U.S.A., Great Britain and Germany was almost double what it should have been. Comparison became possible between mills of different design, because the quality of crude steel became much more uniform and consistent with closer study of the relationship between the blast furnace and the steel plant, and with this the pneumatic process with its much lesser melting time began to approach, if not quite to equal, the basic open-hearth process in homogeneity and quality of output. It had long been known that the Bessemer process could produce more regularly the type of steel suitable for making deep drawing sheet; and the rehabilitation of this process was the beginning of the modern integrated steel mills. Action and reaction of materials upon mechanism and mechanism on materials never ceases; and many of the new studies of plastic flow meant new designs of mill housings, of mill drives and of course formations. Economically all these developments meant a heavy increase in the capital cost per unit of potential output. In the years immediately preceding the War, the increase was about fourfold; since 1948 it is rather more than tenfold. That is not, however, the end of the story. Parallel with the production of steel strip of uniform section and of consistent quality the machine tools were brought forth to use it. Various forms of pressing and forming plant were scaled up and there came into being the very heavy presses working on dies of very large size and expensively fabricated, which are uneconomic in use unless they can produce many thousands of identical pressings.

the use of aluminium

Aluminium and its alloys followed a not dissimilar pattern, which was accelerated greatly by the use of aluminium in the rolled and forged condition for

airframe structures. Here a number of complex problems arose. The shapes of bar needed were often of asymmetrical section, either gauged to shape by planing tools or on plano millers and later, as quantities justified it, formed on extrusion presses. The extrusion press in its turn was applied both to mild steel and to alloy steels and with the discovery of glass as a lubricant could handle complex sections in these more difficult materials. Its latest rival is the draw bench.

Big machines need big machines to build them and machine tool design and production falls into two very broad classes, the very large and the relatively small. Large machines are almost wholly the creation of the middle 19th century and were greatly stimulated by the demands of naval development. The main prime mover, the steam engine, became increasingly large, and its power output was for practical purposes a function of its size. These massive engines, mostly single-acting, gave rise to one of the most active practical research organisations, the Manchester Steam Users' Association, to whom we are indebted for much of the research work on the properties of steam and, ultimately, under the impetus of naval requirements, for the development of the triple and quadruple expansion engines of the immense "three-decker" type which powered naval vessels until the advent of the turbine.

These large engines and the heavy armament of the mid-19th century navies could not be without the use of heavy machines: very long bed lathes for propeller shafts 50 ft. - 60 ft. long; heavy hydraulic forging presses to handle 60 - 80 ton ingots; parting-off machines with cutting heads to part ingots 40 in. in diameter; massive short bed lathes with heavy face plates. Some of the best records of these times are contained in the note-books and sketch-books, still largely unpublished, of Joseph Whitworth and James Nasmyth. Many of their sketches are intended to illustrate how much more compact machines could be made if only the materials available to them were consistent and homogeneous; and possible flaws and cavities compensated for by massive cross-sectional areas and the avoidance of initial shocks in operation. One thing is certain: that is that Great Britain was fortunate in possessing in Cumberland deposits of iron ore with astonishingly low phosphorus and sulphur contents, and in the possessing of coal almost sulphur-free. This made possible the production of sound quality steel capable of producing forgings even by the rather slow methods then in use, which inherently were sound and capable of being treated in sulphur-free atmospheres in coal-fired reheating furnaces. Even with these advantages, disasters were not infrequent and at one time James Nasmyth found himself reduced to using as his base material for locomotive side-rods masses of old horse-shoes, well mill-hardened and carefully balled under a 25 ton steam hammer.

Many of the big machine tools which these big units needed survived until the end of the First World War, and several of them into the Second World War. Some of them were used to make the columns for the 50,000 ton and 75,000 ton presses designed for improving the physical properties of aluminium alloy sheets. The history of these plants raises the whole question of the economic value of such massive machines. The problem relates not only to the machines themselves, but to the nature and size of the services they need for their operation. The replacement of the steam engine by the steam turbine and, later, by the various types of motors and motor generator sets, represented a severe contraction in the volume of work these machines had to deal with; and it was only with the advent of the concept of the central power stations that they once more became effective on a reasonably large scale. But for the demands of two naval programmes for capital ships, few of the large diameter boring mills, the long bed planing machines for armour plate, or the long bed lathes for propeller shafts would have survived the 1920's. Many of them did indeed disappear; and found their replacements in the demand for the tools of mechanised warfare in 1939 - 40.

A large machine can do small work; but no small or medium size machine can produce very large work. There is a strategic as well as an economic compulsion to produce large machines. For example, the development of the large horizontal spindle borer was due to the sudden, almost revolutionary, demand for heavy rolling mill equipment for fast running rolling mills for steel and aluminium; for the construction of extrusion presses of upwards of 5,000 - 6,000 ton capacity; and these were adapted for the machinery of tank hulls from armour quality steel. The very large vertical boring mills associated with the name of Berthier have made practicable the machining at one setting of large diameter steam turbine casings; and machining times on these machines are startlingly less than the time required for similar work on old machines.

In the abstract this is, of course, a great advantage but the larger become the individual components to be shaped on such machines, the fewer are the number of units incorporating them, and the machine becomes a striking example of non-economic efficiency. The problem of reducing mechanical noise in large passenger ships and of reducing maintenance costs and improving sea-keeping times has led to the redesign of turbine gearing, with limits of tolerance only to be achieved by improved types of gear-cutting plant. Of this, probably far more has been installed than any normal peace-time demand could keep fully occupied. In the aircraft industry, special machines have been designed to enable the main members of a supersonic aircraft to be machined in the fully hardened condition, so as to eliminate the risks of distortion in subsequent heat treatment. The machine tool industry both here and in the U.S.A. came in for some fierce criticism for its failure to design for production, on a commercial scale, a machine for which the maximum likely demand was five or six at the most.

a strategic requirement

It is unfortunate that as actual or potential weapons grow in complexity, some part either of the weapons themselves or their plinths or means of transport appear to require the use of one or more machines of

extreme dimensions, and possibly of materials very difficult to form. The result is that any form of export potential is unlikely: and the possession of large machines becomes a strategic requirement of a modern state. Modern atomic energy power stations have posed problems of a similar nature to those which arose in connection with large rolling mill housings, namely the provision of long, wide and very thick plate. The only mills capable of rolling these were the remaining large armour mills, each of them at least 60 years old. It is therefore not unfair to draw the inference that any large machine designed and installed for the special purpose of handling pieces beyond the limits of size of commercially needed articles can never be economic. They have a high prestige value — the sort of thing no gentleman's country should be without; they may have a high strategic value, provided weapons follow that kind of pattern. But they are essentially of the same nature as a siege train. It is improbable that machines of this type will be required again. For more is understood today of the properties of materials of construction: and laminated and lattice construction will play a much greater part. But it is the big machines which have made both their own components and the component parts of the massive rolling mills and the massive engines which drive them; which forged and machined the heavy hollow forgings which were the basis of the high pressure steam plants of today and of the well-head separators of modern oil wells. But, as in the organic world, there appears to be a size limit beyond which inherent weaknesses make themselves felt; and this is what is happening today.

the small machine

Let us turn from the big machine to the small machine — the machine which did not need a separate drive but could be driven from line shafting from stepped pulleys; very much smaller in its working parts, though cumbrous enough in the heavy bed deemed necessary to secure stiffness and freedom from vibration. The power transmitted by this form of drive was very variable; and the accuracy of the work depended almost wholly on the skill of hand and eye of the operator. The proceedings of many technical societies in Great Britain, the U.S.A. and Germany and France are full of records of experiments conducted to determine the optimum speeds and feeds for use in the cutting of cast-iron and brass.

Much of this work was most useful in the way in which it affected the design of lathes: and here again the work of Joseph Whitworth was most prominent. He was himself a first-class craftsman and understood how important for repeatability was accuracy in the lead screw and accuracy in machine alignment; and he equally realised the value of sound tool design. The skilled fitter and turner was his own tool designer; the shape of his cutting tools was one of his most closely guarded secrets, and the combination of hand feeds and specially framed tool forms often meant that a craftsman's competence was very nearly confined to a machine with which he had become familiar; and "shop limits and fits" often meant what the triple combination of craftsman, machine and tool could do. Material was far more expensive than labour and saving of material was of greater consequence than the saving of work; and cutting times were not necessarily a decisive factor in competitive engineering. Cutting tools were mostly formed from hand hammered bars of .9% - 1.2% carbon steel in square and round form. For very tough or hard spots, occasionally met with in grey cast iron, a cast tool of mute hematite was used; it did not last long but it dealt with the problem. In Europe, the Swedes; and in the West, the U.S.A. developed a number of relatively small tool-making shops producing cutting tools for machine tool operators and with this development came a separation of tool room from production work. In Great Britain the process was slower but still along the same lines and was encouraged by the fact that machine tools themselves, especially lathes, began to be built on a reasonably standardised basis — the makers' standard, it is true. But it was not till P. H. Taylor, in the early years of this century, began to think how the yield of labour could be increased that the first real steps to repeatability of work were really taken.

Again his work coincided with the coming of high speed steel — a British invention, which so far failed to make its way with tool-makers that the makers of high speed steel were themselves compelled to become tool-makers. For many years a number of engineering concerns preferred to make the cutting tools needed for their machines in their own tool rooms, or even permitted their own machinists to retain the making of the tools they needed. Even today there is quite a trade in "tool-bits", pieces of round, square or hexagon bar, now usually welded to a carbon steel shank, to remind us of the days of the tool-makers' mystery. A tool, made specially for a particular or special operation, may well perfom better than a standard design intended to cover a multiplicity of cutting conditions; but its labour cost may well be two or three times the cost of the factory-made product.

While Taylor was making his great investigation into machine shop and production shop practice, there came into being for the first time the production of symmetrical steel joists, which meant a large reduction in the cost of steel structures and began the great controversy between punched and drilled holes for riveting. Drilling in cast iron was never really difficult, but drilling in steel with its higher tensile strength and tendency to form ribbons was a different problem; and the early twist drill — chiefly because drilling machines tended to drift — had an unpleasant knack of breaking off short in the hole. So with improved punch steels, the many mechanical punching machines had a new lease of life; and many theories were developed about the better elastic properties of a punched and wrought iron riveted structure. It was probably true because the punch work hardened the hole and stiffened the material quite considerably. The growth of shop fabrication, the use of the radial drill and the more accurate marking-off it needed brought about an advantage to the drilled hole which it has never since lost. The twist

drill with its multiple tapered flutes and its follower, the reamer, were the first repetition tools to be produced on repetition machines; and even today they constitute the preponderant part of the engineers' tool industry.

This period — the first 15 years of the 20th century — was one of immense confusion. Most of the familiar names in the machine tool industry of Great Britain, the U.S.A., Germany and France were already in existence; very few were building anything like standard machines. There were too many "special orders" to meet the demands of a variety of users: and individual drives for machines were only available in a few favoured districts where alternating current was available from public supplies. But with some 300 different supply authorities and many more hundreds of factories with their own — mostly D.C. — generating systems, there had to be a great diversity of machine tool types even within the same range of machines. Progress was, however, being made. The advent of the steam turbine, the demand for more compact pumps and compressors, the advance of the internal combustion engine, had a twofold effect. They created a demand for repeatable parts, a demand hitherto mainly confined to the textile machinery industry and the manufacture of military small arms and ammunition; and also introduced the technique of amending the relative shortage of skilled labour by the use of jigs and fixtures. The introduction of the electric arc furnace brought about a substantial increase in the tonnage and quality of tool steel and high-speed steel, so far made a few hundred pounds at a time in carbon crucibles.

the psychological outlook

It is interesting to recall the difference in psychological outlook, which resulted from the war of 1914 - 1918. Up to that time, the machine tool was a device which merely extended the skill of the skilled man. During the War the machine tool became what it has since remained, an instrument of production, and every development of it has been to improve the yield and accuracy of its work. What we may describe as the finer machines, the milling machine and the internal grinder, owe their growth to the demand for time fuses during the 1914-1918 War; and from that War stem also the multitudinous devices for automatic or semi-automatic operation of the slides and cross-slides of machines and the indexing mechanism of the capstan. None of these would have come into being without previous improvements in the accuracy and durability of gears. The invention and production of ball roller bearings, with the work of Palmgren and Hoffman, solved many difficult problems of bearing sizes, and housing dimensions were solved.

Perhaps the most significant revolution in the conditions surrounding the advance of the machine tool was the standardisation of the frequency of electricity. Without that, the built-in standard drive would have become hopelessly complicated. This indeed was one of the most difficult problems of production during the War of 1914 - 1918; in marked contrast to the Second World War, the problem of the location of war industries was greatly simplified.

War is a great accelerator; and the initial experience gained in the art of multiple production carried into automobile production machines and methods learned in the business of war. A great — perhaps too great — a part of it was based on aero-engine practice in which there was little specialised production of component parts. Most of these were machined to individual dimensions in the actual engine factory. The aero-engine has however this advantage: every possible ounce of power must be got out of given dimensions and the power to weight ratio must be the highest possible. Jig and fixture design was improved and the jig-borer as the preparatory machine to production became fully established. The political revolution of the trenches created a potential automobile market which could only be exported by a series of low cost cars. Not many survived the depression of the '30's. Inherently the smaller cars were too expensive; their machinery limits were inexact and selective fitting of multiple units meant economic ruin. This was not unnatural, however. The aircraft engine was in its infancy; there was no accepted standard type with the possible exception of the Gnome-le Rhône. There were few special-purpose machines; and most components needed machining from the solid with a disproportionate amount of hand gauging, with a corresponding inordinate demand for skilled labour.

demand for specialised tools

The experience was, however, valuable since it did create the demand for more specialised machine tools and especially for more compact and more easily fed machines. The first steps were taken to the grouping of machines to permit successive operations with one setting — the forerunners of the modern transfer line. What is owed to this period is the appearance of forming machines for the forming from light plate and sheet of a series of asymmetrical sections, and a series of mechanical presses which again developed into the heavier presses now used for many automobile and vehicle components. These, to become fully effective, had to wait for the appearance of deep-drawing quality sheet, in which Germany and the U.S.A. were far in advance of Great Britain.

To no small extent production methods and the machines to apply them were retarded by the severe economic depression of the early '30's; but as the country emerged from it, the ideas and conceptions pioneered in this country by Lord Nuffield began to take form and shape. The specialist maker of components emerged and the automobile industry began to assume the shape it has today. A whole new family of machines came into existence to meet this demand, designed for easy feeding, much higher speeds and easier clearing and much more powerful than the generation which preceded this period. There was still a tendency on the part of some builders, especially of centre lathes, to underpower their machines. Many users had already reached the conclusion that a machine tool was intended to be driven hard and drove them hard with outstanding success. It was as well they did for new cutting media were on the

way, capable of far higher cutting speeds but requiring much finer feeds with a minimum improvement of machining times of upward of 25%. This applied both to cutting tools of cemented carbide and the synthetic grinding wheels with carefully controlled gram sizes; and both suffered from the same disability that barely 15% of the machines in general use could employ them even to one-half of their inherent capacity. They were relatively fragile and were ill-regarded in many shops as the harbingers of cutting of piece-rates. Their ultimate effect was to render obsolescent a large proportion, probably something like two-thirds, of the machine tool population of the country.

Simultaneously another change was in progress, namely, the increasing use of aluminium and its alloys in airplane construction. The machining of aluminium, especially the durals, presented machinery problems of a curious kind, and only by trial and error did it emerge that these metals could be cut at four times the speeds used for ferrous metals, and also required special designs of cutters for the best results. Further, extremely high speeds were needed. Quite a number of good-class milling machines could not match the speeds required and very few lathes could get the power needed.

ceramics and cemented carbides

The change from high speed steel to ceramics and cemented carbides meant a revolution in machine design and performance of which the real economic impact was damped by the demands, first of the Second World War and, later, by the mobilisation of resources imposed by the Korean War. There were of course many machines unaffected by this change. Maintenance machines from which high production rates were scarcely needed were hardly affected; neither were the vast numbers of drilling machines, for the technique of producing twist drills with cemented carbide cutting edges was still not far past the stage of experiment. But every form of lathe tool, whether centre lathe or capstan, vertical boring mill, shaper or slotter, needed redesign before they could get the full benefit from the new cutting media. Not many of them got in except in Western Germany and Sweden. In Great Britain and the U.S.A. there was something approaching a compromise, because in the application of machine installations there seemed to be sought a suitable balance between fast cutting of certain components and slower cutting speeds where smaller batches had to be balanced with larger outputs. This is a very difficult problem in itself: and it has had as its consequence a notable trend towards specialisation in component manufacture, especially in the automobile field.

The consequences of this naturally are that there is far less necessity for the concentration of all manufacturing processes in one area and a much greater dissipation of centres of production is practicable. The social benefits in the modern state of decentralisation of the productive process are to be preferred to the more complex problems which have had to be faced when industrial demands have led to sudden population increases as in Coventry, Bristol and, not least, Oxford. Much of this policy of devolution was anything but deliberate. It was an inheritance of war when dispersal was essential; and afterwards economic life was fitted into the pattern of resources in works and services created for war needs; and what might have been a slow processs of differentiation was greatly accelerated.

the demands of war

Again, the shadow of war brought new problems. The Korean crisis of 1952 brought once more the demand for the more advanced land response evolved during the latter part of the 1939 - 1945 War, with a further new call: the call for the construction on a large scale of the internal combustion turbine. The heat resisting steels of which these engines were built were very difficult to machine and there was no standard method for making the blades of the turbines; still less for gauging the accuracy of the finished blade. The fuel feed and ignition systems presented awkward problems, less complicated but no less important. Four new aero-engine factories had to be established and each of them needed machines generally of a size which represented the extreme range of the production models available.

It is probably true to say that no country in the world produces every type of machine which its industry even in normal peace-time conditions requires. There is no trade in which there is a greater interchange of types of machine than the machine tool trade; and none which reflects more clearly the sort of industrial pattern which each particular country enjoys. The maximum war demand is for the fringe sizes of machines both large and small, together with a great increase in the means of producing jigs and fixtures and building prototype components on very accurate machines. The economy of Great Britain in 1952 was directed principally to the recovery and maintenance of the export trade; and a vital decision had to be made whether to swing over to war production the whole of the machine tool industry at home, or to devote a considerable proportion of the country's overseas earnings to the purchase from other countries of much of the conventional machine tool equipment required. The defence programme of the three services called for about 18,500 machines, apart from the demands of normal industry for replacement. The British machine tool industry could produce — apart from a number of small general purpose machines — about 60,000 machines a year, of which some 24,000 went into the export market. An embargo on export would have meant the sacrifice of many traditional markets both inside and outside the Commonwealth; and the decision was taken to continue exports with the minimum of interference and to purchase from West Germany, France and Italy about 12,400 machines to supplement what could be taken from home industry. The remaining machines, about 6,000 in all, came from the U.S.A. Most of these were critical machines and were delivered in about two years, and by far the greater number from Mutual Aid Funds. It is significant that during this period there was carried out on behalf of the U.S. Government a detailed survey of the

machine tool resources, both in factories and in the potential of machine tool factories, in the whole of Western Europe.

The decision of the British Government was an economic decision and in the circumstances was undoubtedly right. It was, of course, seriously criticised both at home and in the U.S.A.; at home because it was charged against the industry that it could not spring to a full war footing at a moment's notice, and in the U.S.A. because Great Britain was thought to be exporting for commercial purposes machines identical with those supplied on Mutual Aid. Of the U.S. machine tool output, rather less than one-quarter of the machines decided by the Director of Mobilisation to be critical machines was available for mutual aid to the whole of Western Europe. About half of this proportion reached Great Britain in the latter two-thirds of the two-year period I have mentioned. British production of gas-turbine aero-engines was far in advance of that of the U.S.A.; for in that period the U.S. suffered many failures.

The criticism of the machine tool trade, of which Mr. Harold Wilson was the chief exponent, was not wholly misdirected; although the critic's conception of a machine tool was a kind of sausage machine into which some undefined material was presented and came out in the form of weapons of war. The criticism did draw attention to the place occupied in modern war by means of production, and what kind of strategic reserve it was necessary to keep, either on machine tool stocks or machine tool potential.

American machine tool stocks at the end of the 1945 War were enormous; and so was the machine tool potential. One of the unregarded achievements of that War was the creation of the American Navy; but the preparations for the continuance of the campaign against Japan called for the production of a great bomber fleet for which — I may perhaps call them outsize — machines were needed and were produced: large tracer controlled millers, large and accurate horizontal borers, spar millers, many of which never worked but for which the jigs and fixtures already were developed. We should not, however, forget that no small contribution to American war equipment came from Great Britain — heavy planing machines for strip armour and heavy parting-off machines to handle forging ingots.

In the U.S.A. the War Department endeavoured to site the new tank engine factories alongside automobile plants, so that by a shift of personnel full scale work could be undertaken without delay. The general concept behind this was that available potential was, in the case of many weapons, much more economical than the existence of large reserves in parks and warehouses. Experience proved that far more man-hours were needed to extract from reserve parks batteries with full equipment, than to assemble them from production lines for which process specifications and full tooling were ready.

progress in Russia

More recently we have learned from Doctor Galloway's Paper and from the Report of Professor Melman of the progress made in the machine tool industry of Soviet Russia; in Professor Melman's case urging that the Western World should do likewise and in Dr. Galloway's case objectively reporting a complete range of fact. None of this is very surprising. Czechoslovakia always possessed an advanced machine tool industry, so did Western Hungary and Poland. Lenin's unswerving purpose was the creation of a "machine civilisation". He believed that the U.S.A. with a population of about 160,000,000 had created a machine civilisation in three generations. Lenin believed that by the sacrifice of one complete generation, he could do it in two: and he has proved very nearly right. Dr. Galloway's observations and the reports of other independent investigators show that the Soviet machine tool factories can produce every type of accepted machine; and their multiple production of these machines is founded upon the fact that there are no alternatives; consumer choice is severely limited. War is the natural consequence of a planned economy with an enormous area to fill.

new cutting media

It would be a much more comfortable life for the planner and the producer if human ingenuity and human demand stood still. Of course it never does, and the invention of new cutting media again bids fair to make obsolescent before their time many machines of almost exquisite ingenuity. The several types of ceramics, chiefly sintered alumina, enable cutting speeds of 3,500 - 4,000 ft. per minute to be attained on centre lathes turning steel plate mill rolls or heavy propeller and intermediate shafts. The metal shavings come away so fast that they stand rigidly four or five feet above the work. Such lathes need 150 h.p. or more to drive them and can handle four or five times the amount of work handled by a more normal machine. Large vertical boring mills, heavy-duty face-plate lathes, plano-millers with more powerful drives can well benefit from these tools. But these machines are long-lived and very rarely end their working life. Their entry into industrial life is either upon an occasion of emergency or upon some programme of concentration of production when time is of the first moment.

The appearance of new cutting media and of new materials of construction to be cut, is today a good deal more frequent and faster than the response of the machine tool designer to them. This is quite natural, since many of these new materials need quite new techniques for their application. The use of nylon for a number of high-speed parts produced some very complex problems of tool design and study of automatic machine speeds and feeds. At the other extreme, new cutting methods have greatly reduced both the cost and the risks involved in the preparation of such items as tools for drawing presses and for gravity and pressure castings. It is now practicable to cut and shape these tools in the fully hardened condition either by electro-erosion or supersonic means and some progress has already been made in the use of electronic cutting. The attraction of these processes is the relatively simple design of the machines needed; they are revolutionary without being subversive!

The development of modern industry now depends upon mass demand and the means of satisfying it. The machine tool has become now a two-fold instrument. In one aspect, it remains what it always was: the indispensable instrument for making component parts of industrial equipment; in its other aspect it has become the indispensable instrument for making quickly and accurately the component parts of a multitude of quasi-consumer goods. It is perhaps fair to say that there is already in process a dual line of development; the distinction between them is as yet not fully defined and will naturally depend upon the shift of emphasis even within a single firm's production. In what I have referred to as the first aspect, the machine tool industry is tending towards the control of the machine otherwise than by the operator. Tracer control of a lathe or milling machine either from a template or from a master had already been well developed in the late '40's, and was a valuable mode of repetition production, even of small quantities. But the original master had to be produced by a skilled man either on a lathe or milling machine, or even on a jig-mill. At least one automatic factory existed some eight years ago, when standard machine tool components were machined on remote controlled machines.

Tracer control is now tending towards numerical or magnetic tape control of machine with preset timing. These devices are similar in principle to the automatic lathe, whether single or multi-spindle. In these latter tools a change of product means a change of set up; in the tape or electronically controlled machine, the machine's motions change in direction and duration as the control mechanism demands.

Both types demand great accuracy and great rigidity in the machine structure and great durability in the cutting medium, with quite a problem in the matter of the lead-in to the workpiece. The cost of machines of this character seems to compel the concentration of many functions within one main framework, and they have the disadvantage of being relatively inflexible when dimensional or design changes come about. The other series of machine tools is more specifically of those installed in the many production and feeder lines which are needed to satisfy mass demand. Here the machines are predominantly single-purpose machines; but even their installation means an expenditure of hundreds of thousands of pounds.

the problem of change

Here the problem of change may be met by changes in tooling; but quite often this amounts to a third or more of the cost of the machine. Apart from the automobile industry, many mass production lines consist of relatively small machines. Even on these lines the production process has a high degree of rigidity, and changes in design or materials used can involve serious expenditure and what is commercially worse, very much loss of output. In the past this problem has been met by deliberate over-production on final runs, especially in domestic equipment lines. The surplus is sold at cut prices. With the growth of competitive demand this is only an expedient; but the increasing cost to industry of the unexpired life of production lines has brought into being two separate but related trends. First, the development, of which Renault were the pioneers, of the unit head and the building of machines on the *Meccano* principle; and, secondly, there is going on serious research into the simplification of the machine-part of the machine tool, into the building of interchangeable sections of the bases and columns of machines to make them adaptable for the fitting of different tables and "arms" of working tools. Both these trends are of real importance, partly because they represent a serious attempt to overcome the rigidity implied in the tailor-made machine and partly because they will help to balance the appalling problem of the hills and valleys in machine tool production.

I have refrained from using statistical illustration. In the first place statistics of the numbers and types of machine tools are extremely misleading; and in the second place, the definition of machine tools is so inexact as to make other than very broad comparisons impracticable. The massive demands of two actual and one threatened wild conflict for small arms for millions of men, for the construction of military naval and aerial weapons and their transport and servicing have, in fact, transformed the machine tool from its original purpose as an instrument of production into a factor in strategic logistics as fundamental as the study of available man-power. It is studied by politicians and their advisers as an element of actual or potential military strength and in that view its flexibility and its capacity for expansion are regarded, and in that sphere of thinking quite rightly regarded, as appropriate qualities to be studied and fomented.

planning for expansion

Quite obviously in every industry there always exist a number of means of expansion, especially if the expansion is in certain limited types; but this probably does not exceed something of the order of 10% to 12½% overall. A further expansion needs longer range planning and in general is only practicable by bringing into machine tool production a number of industries whose product is akin, such as manufacturers of printing machinery, of material handling plant, knitting and weaving machinery. A secondary but similar stage is the duplication of existing plants. The problem here is not the installation of plant but the provision of the several jigs and fixtures indispensable to the operation of the plant. These very rarely exist in duplicate or even in detailed form: shop modifications impose all sorts of minor but significant differences. The almost natural reaction to these problems is the creation of the so-called strategic reserve. Experience shows how dubious is this policy. Even in temperate climates slides and surfaces corrode; lubrication cannot be maintained and the man-hours needed to bring to working order a machine stored even under ideal conditions is too extravagant to be tolerated.

It must always be realised that change — and imperceptible change — is continuous and its extent is only realised when, for example, you undertake

the rebuilding of machines which have already done much service. It is part of human frailty that what goes to strategic reserve is not the desirable but the less desirable machine, and by the time the less desirable machine is needed it is even less desirable. There has quite recently been a notable illustration of this in the very well-intended release from the U.S. strategic reserve of machine tools by way of economic aid to certain Eastern countries. The mouth of the gift-horse is most deeply scrutinised where the probable use of the machines is for normal economic development. On the other hand, Import/Export Bank loans have been expended upon new machines of the most advanced type although the technical resources for their use are imperfect.

the systematic view

I have already referred to Professor Melman's Report which is only so far known in outline from his precis as delivered on television and radio. The Report of the Committee of D.S.I.R. is not yet available; but there is little doubt that it will seek to indicate some systematic view. The misfortune of systematic views is that they are valid only for a particular set of circumstances envisaged as desirable for an assumed or explicit policy. This may be strategic or economic; both may be completely at variance with commercial need. Machine tool builders are not philanthropists nor can they afford to build expensive prototypes with no visible future demand. Machine tools are instruments of industry and exist only insofar as they make practicable the manufacture of a wide range of components. They have to be modified as the means of cutting and shaping alter, as the scale of the components or the materials composing them change. For example, in the guided missile field, very thin sections of stainless and heat resisting steels are welded up into shapes, which with improved metallurgical practice could be much more readily spun from thicker section material.

It is a not uncommon conviction on the part especially of Governmental departments that the size of an organisation is a *prima facie* condition of its efficiency. The machine tool industry in Great Britain covers about 350 - 400 firms; in the U.S.A. there are about 250. Here again we are faced with problems of definition.

There has been in progress during the last five years a consolidation of machine tool makers in the U.S.A. and on a smaller scale in this country: but there has also been an increase in the number of tool-making firms whose products are often hard to distinguish from machine tools. Partly this is a social phenomenon somewhat similar to the growth of the electronics industry, built up by small independent groups of specialists as well as by the research organisations of the larger electrical firms. Some of these coalesce into larger units with a standardised basic production and an effervescence of fringe products. That is precisely parallel to the growth of the machine tool industry. The average age of the machine tool population of Western Europe and the U.S.A. is about 10 years — half of it about 15 years and half of it five; the five year group is the group of high production machines mostly in the automobile and allied industries; and the proprietors of these machines would like to lift the average to something like seven or eight years. This should be quite a practicable aim if the bases and drives of many machines could be suitably standardised to take a number of diverse tool holders and tool-settings.

This, of course, raises the whole problem of the reasonable limits to which machine tools should be built. Quite a number of tentative proposals have been made, of which the most comprehensive was that of Dr. Schlesinger. It has proved in international negotiations an extremely difficult task to arrive at agreement upon what tests should be applied to a machine tool. It is unfortunately true that a machine tool built of carefully gauged components may not be a good machine tool; it should be, but in practice it often is not. Equally, there are very few machines which cannot be made to perform more accurately by careful reassembly. It is also generally accepted that a reasonable standard machine may in the course of its working life have to deal with a number of materials presenting more or less difficulty. Usually they do this quite satisfactorily. For specialised machines such as single and multi-spindle autos, the only valid test is the ability to produce a range of products at a timed speed. So many machines are, however. purchased today to machine specified pieces within specified limits that the older practice of shop limits is really no longer tenable.

guarantee of compliance

Within the European Common Market there is no doubt whatever that machine tools will carry a guarantee of compliance with specified geometric requirements. The Russians do this already. It has been their practice to dismantle a machine into its component parts and examine every sub-assembly in detail, making copies of each one. It is an expensive process in man-power but far less expensive than creating working drawings and translating them into a different measurement system. A similar method was used in this country for certain specialised aero components and will no doubt be used again.

The machine tool industry is an instrumental industry and it is international. It embodies the brains of designers who study the most economical way in which metals, wood and synthetics may be shaped internally and externally; it adapts its products to the techniques of other industries; for example, the radial drill was the adaptation of the drill to boiler shells and structural steel. It had to solve many problems of vibration before they were known or appreciated in general engineering. It has moved with the advance of metallurgy. No country has at all times produced all the machines it needed for its own industries and the developments of machines has, in its turn, depended upon the specific types of engineering equipment to which the machine was a specific response. The design and building of the large horizontal borers arose from the demand of the builders of heavy rolling mill plant; for the large

vertical boring mills from the demand for water turbines and later for the casings of high powered steam turbines; the heavy milling machines with their spacious tables were the outcome of demand of the aero-engine and airplane industries.

A number of these complex machines suffered from the fact that they were "blown-up" from smaller models; and they were anything but easy to feed or unload and suffered from a lack of "get-at-ability". Successful machine tools must fit into a general pattern of systems of production; and the endeavour to require that every machine must be tailored to fit an individually desired system is wholly uneconomic.

REPORT AND DISCUSSION

THE **President,** Mr. G. Ronald Pryor, extended a cordial welcome to all those attending the Lecture, and at the same time thanked the authorities of the Royal Institution for allowing The Institution of Production Engineers to use their wonderful Lecture Theatre, which had so many traditions behind it, and which could not be bettered as a venue for the presentation of the Institution's Named Papers.

It had been the practice of the Council of the Institution from time to time to institute Named Papers, honouring those distinguished members who had done so much for the Institution and for the profession, by attaching their names to national Papers by distinguished authorities on special subjects. The Viscount Nuffield Paper was established in 1953, and the first was presented by Lord Sempill, who was a predecessor of Lord Nuffield in the Presidential Chair of the Institution. Lord Nuffield, of course, had a special place in the hearts of members. He had been a very great benefactor of the Institution, and it was due to his generosity that in 1938 it was possible to start, in Loughborough College, the Institution's research department, which had now developed into the Production Engineering Research Association of Great Britain.

The 1960 Viscount Nuffield Paper was a worthy successor to a long run of interesting Papers, and to deliver it Mr. Pryor had great pleasure in welcoming Sir Stanley Rawson, who needed no introduction to members of the Institution. It might be pointed out, however, that he was, and always had been, extremely interested in the subject of standardisation.

Sir Stanley Rawson, presenting the Paper which appears on pages 549 - 558, said:

I am very sensible of the honour which has been accorded me in being invited to present the Viscount Nuffield Paper, particularly in such august surroundings as the Royal Institution. The subject of the Paper is one to which I have given a good deal of thought from time to time.

It so happens that I have lived quite a long time, and when looking back over that length of time I recall two landmarks. The first concerns the house in which I lived at the age of five or six years. It was lighted by electricity which was generated by a dynamo driven by an Otto gas engine running on town gas, the engine being of 3½ h.p. and weighing 3¼ tons. The second landmark concerns the last engine with which I have been privileged to be associated, which weighed .6 lb. Those two factors in approximately 65 years make one realise what progress has been made in the generation of power, and with that power there is the progress which has been made in reliability and consistency of materials and the means of handling them.

In the Paper an endeavour has been made to give a conspectus of the place which the machine tool industry has occupied in this development. It is inseparable from metallurgy, inseparable in a two-fold sense. One is that it depends for its own being upon materials, and it depends for its own function on materials, and the way in which, one might almost say, the apparatus of civilisation has developed has been conditioned by and conditioned the development of the quite extraordinary machine tool industry. It is a very old industry, and puts to its own use all the various devices which have made for the easier application of power. It also depends upon the development of materials outside itself and the techniques which have been established.

The problem presented by the Paper was not what to put in, but rather what to leave out, and I decided that it was best to leave out statistics because they meant very little.

It is impossible to devise a definition of a machine tool which does not leave too many rugged edges and which is not false inside two years. For various purposes definitions have been attempted, and the only comprehensive one was for the purpose of controlling the price of machine tools in the 1939 - 1945 War. Everything was included in that definition of a machine tool which could possibly be included, even up to a rolling mill, hydraulic press extrusion press or mechanical press. At the present time, there is a tendency to go to the other side and to restrict "machine tool" to power-driven instruments; and in considering electronic applications to the machine tool, where does one stop?

There is another problem which always presents itself in respect of such a matter, namely: in the machine tool industry there is a cardinal example of

how the engineer very often knows how, but takes a long time to find out why. From the engineer's point of view "why" does not matter, and generally speaking the "how" of many processes referred to in the Paper are very familiar and well-known, while the "why" is a complete mystery. The "why" of much of machine tool work today is very mysterious and still unknown, chiefly because no one quite knows the technique of cutting. A great deal of work has been done on it. The use of high-speed photography can help a great deal, but what is not known is precisely how the surface of metals differs from the interior. All that is known is that there is self-repair of the surface, and that the surface is of the greatest possible importance in the final strength of the material.

a mistaken approach

I have drawn attention to the somewhat humiliating fact, from many points of view that no matter how complex a machine tool may be, its primary function is to make sure that the cutting medium is in contact with the work. Looking at a very large number of machines I have been shocked to discover the difficulty of access which many expensive and well-designed machines offer. At the same time, I have been equally shocked by the effort which is made to build more and more complicated machines almost, one might say, for the fun of building them.

In addition, it has to be borne in mind that one of the functions of the machine is to take the difficulty out of the work. The skill of the craftsman is of great value, but it can be overrated, and the function of the modern machine is to make the skill of the few of great importance, and to take out of the ordinary work of the machine shop a great deal of the personal knowledge in that element. This is partly conditioned by the fact that it is necessary to be able to work today to limits of assembly, and it is undesirable to do a great deal of correction. I recently visited a factory and was shown in particular an inspection line for connecting rods of the ordinary motor-car engine. The line cost something like $4,500,000, but the connecting rods were gauged on 60 points and passed three times through the circuit before being rejected. The accuracy of measurement of those connecting rods is within the limits of $2\frac{1}{2} \times 1$ ten-thousandth. That explains why the modern motor-car engine will stand an amount of rough usage that it would never have stood 25 years ago. Similarly, the amount of attention which is given to the size of cutting tools and to the design of the cutting tool itself has made an equal contribution to the efficiency with which the work is carried out.

These things are taken for granted. In fact, too much is taken for granted. When dealing with, say, the half-shafts of a big lorry, the steel out of which they are made probably comes from a 95-ton cast of steel. Less than 15 years ago it would have come out of a $1\frac{1}{2}$-ton cast, and in that time it can be certain that the piece of material which comes from the 95-ton cast is homogeneous, and can be relied on to have repeatability of the order of 90% if other tests are carried out on the cast. Twenty-five years ago on a $1\frac{1}{2}$-ton cast the repeatability was 60%.

There is another factor to which attention should be drawn. Like every national function today, politics to some extent are bound to have their effect upon the machine tool industry. I have endeavoured in the Paper to show what a great stimulus the demand for military equipment has been to the machine tool trade. Military equipment covers a wide and vast area. It is improbable that in any future wars there will be anything like the same insistence upon repeatability and consistency that there has been in the wars to date. Quite clearly, much more will depend in the future upon very small pieces of apparatus attached to very large pieces of apparatus, and it is highly improbable that the demands of ammunition and the means of throwing it which have been met in the past will be encountered in the future. It may very well be that when the industry thinks of what it is going to be called upon to do in the future—from the point of view of defence or attack — those concerned will find themselves working with very large pieces whose weight is very much less than anything they have been accustomed to.

For example, in the modern refinery one of the present-day requirements is a metallic sphere which is as near perfect as can be obtained. The same thing applies to the modern atomic energy plant, where it is necessary to have very large pieces of apparatus which have minimum weight and maximum accuracy. Forces are being dealt with where some slight deviation from normal trajectory can lead to disaster.

the revival of crafts

It is curious to find how many of the forgotten arts and crafts have been reintroduced in modern times. For instance, with regard to the apparatus designed for modern guided missile production, a great deal of effort has been put into welding-up out of extremely thin materials complicated shapes which 30 years ago were spun on a lathe. The art of spinning is one of the forgotten arts revived in order to make some of the complicated apparatus which is necessary.

In the future, the industry will be faced with more and difficult materials. At the present time, in a great many applications, it is necessary to deal with man-made fibres, the machining of which is a different operation from the machining of metal. Demands will no doubt, in time, become even more exacting, but the response to what is required will doubtless be found in straightforward, common sense machine tool design. The machine tool designer has not failed yet, and there is no reason to think that he will fail in the future.

There are methods of cutting and shaping which are only in their infancy. To take, for example, one of the hardest artificial materials known, a tungsten carbide disc, it is possible to drill a complicated hole through it in roughly eight minutes at the present time. There are at least three ways of doing it, and within the next year there may be half-a-dozen. But all these methods require in the material a consistency, a repeatability and stability which many of them do not as yet possess.

the use of ceramics

Most of those at the present meeting will have seen the work being done with ceramics in cutting, and the special application machines which have come into being, particularly the new type of hardened steel roll which is required for work with the modern type of strip, both in the very easy and in the very difficult materials. This roll will stand up to service in a rolling mill for as long as five or six times the period of service of the former type of roll. There is another side. I recall in 1935 or 1936 seeing in Germany an attempt being made, which finally proved successful, to wind 3 in. plate on a helix, to weld it up and form a solid forged tower for a refinery. A similar attempt was made in the case of 2½ in. thick plate and boiler drums for high pressure steam plant. This process was revived after the War with less thick material, and the result was a remarkably strong structure of helix welding of very thin material which would not only act as a container, but also as a load-carrying medium. Does one call that piece of apparatus a machine tool? Because it *is*, and more will be heard about it in the next 5 or 10 years. No doubt it will encounter difficulties and troubles, but it is an example of how impossible it is to stand still, and just as in the last 100 years the British machine tool industry has met every demand on it, so it will meet the new demands.

Many of the machines to be seen have been in existence scores of years. The only difference is that they are individually far more reliable than they were. It will be apparent from some of the facts outlined in the Paper how much dependence there is on what was described as the surrounding industrial atmosphere. Can one imagine today what it would be like to have to supply machines to a country which has 280 different frequencies in its power supply? That was the situation in the United Kingdom in 1921.

difference in evolution

One important point to consider is that it must not be thought that the undeveloped countries are going through exactly the same evolutionary process as Britain went through. They will skip 10 or 12 generations, and the psychology of the new countries is that they must have the best of everything and it must be absolutely foolproof. Some progress has been made towards that, but the goal has not yet been reached. It is better to think in terms of providing a high-class machine rather than in terms of providing a humdrum machine which, although undoubtedly it will be required, will not be wanted at first.

I have referred in the Paper to Professor Melman's Paper which he wrote for the American Military Aid Committee. It is a most intelligent Paper and one in which the author recommends that there should be, as it were, a rationalisation of the machine tool industry so that no machine, however complicated, would be produced other than on the mass production line. If one looks at the machine tool industry and the aircraft industry, it will be seen exactly how those two methods of thought and development contrast or compare with each other. Every aircraft designed in this country is designed on the assumption that 1,000 of them will be constructed. Every machine tool which has been designed in this country has been designed with the idea that 20 might be constructed with luck, because it is necessary to build them commercially for a particular range of customers. If one were to start with the idea that every new machine designed has to be built in lots of 1,000, the business would be conducted in a different way from that in which it is carried out today.

It has not been possible to do otherwise than repetitive production in the machine tool industry. That is characteristic of much in the U.K. and it generally works out reasonably well in the end. There is one factory in Britain which has the highest output per square foot of floor space of any machine shop in the world. Equally, there are machine tool shops in the United States which have built complicated machines and are very much better at it than the industry in Britain. At the same time, there are some which are worse.

complete automation

The only completely automatic factory I have seen is in the United States. It has some 42 machines which are fed in the morning and at noon, and the components removed twice a day. Nobody goes into that factory at all except the feeders and the people who take away the products. The machines were controlled by punched cards, but by now they are probably controlled by magnetic tape. The variation in the components produced in that factory is less than 4%. That is what can be done when the demand is there, but whether it is the right thing to do when the demand has to be created is quite a different proposition.

With regard to the question of standardisation, there is in general a great deal of difficulty in putting over the ideal of standardisation in an old industry. In the international standards field it is a reality, and there is a great deal of discussion going on concerning the question of the limits to which machine tools should be built. Curiously enough, in a complex piece of apparatus such as a machine tool, the primary function is to do the work that is expected of it, and to do it accurately. It is probable that many machines built to extreme limits of accuracy are not as good at their job as the machine which is less accurate in some of its component parts.

To take by way of example the straightforward automobile, one could put in a first-class engine, a first-class gearbox and a first-class transmission, but the result is not necessarily a first-class motor-car, because three systems have to be balanced. In an analogous fashion, the machine tool is a balancing of three or four systems, and to bring them to the point at which they assist each other is still a problem which can only be solved by the application of a great deal of skill and thought.

When Professor Schlesinger produced the limits for machine tool production and his work was published by The Institution of Production Engineers, it marked a great era of progress; but it did not necessarily solve the whole problem, and much work still remained to be done to ensure that by making individual components which were quite accurate in themselves, no imbalance would be introduced which would make the machine tool much less effective. That was one of the problems which has not yet been solved, but it will be. The work of experimentation which is going on in that direction is bound to succeed in bringing those concerned to a point where it can be said that a machine is of Class A, B or C, if it is known what sort of machine is wanted.

The man who wants a machine should know what he wants and should realise what he wants. In one instance where a colleague and I had occasion to examine a number of multi-purpose machines with eight positions on the turret, we found that two positions had been worn almost to glory, and the remaining six had not been used. Again, the amount of equipment which has been ordered with machines and which is still in grease-proof paper after seven years of storage would shock many people. It is not good business to sell equipment which is not wanted. There is a good deal to learn about the people who use the machines and the people who build them.

Dr. W. S. Hollis (*Ministry of Aviation*), who opened the discussion, said that in reading the Paper he had been struck by the fact that all the mechanical sciences of our age could be grouped into four major faculties. The author had shown, too, that the significant phases of advance in manufacturing methods had accompanied the business of war. This was perhaps the only time in our industrial history when the green light shone for production by the best available means. The collective progress and technological gains led one to believe that a similar philosophy of encouragement in more benign periods would yield, at relatively little cost, immense advances in the field of metal manipulation and cutting.

The special purpose machine had been referred to in the Paper. The motor-car industry used a considerable number to great advantage, but it was fundamental that the special purpose machine must develop around military strategy. In the military field it was interesting to examine how the application had extended from simple production use to becoming a limb of research. Originally, as a production aid the machine tool was ordered with the jigs and fixtures at the full production stage. As military designs became more complex, the designer needed to be fully assured on the constructional methods to be adopted before he could hang his design around them. Manufacturing methods, then, for the first time had become a serious consideration since the prototype and the associated structural testing was committed to a mode of construction. So the tools of manufacture gained status.

A more important feature which was emerging was the capacity of precise reproduction demanded in the experimental stage to eliminate manufacturing variations. Variations in the experimental or even in the laboratory stage could produce wide band results totally unsuitable for modern research, and the degree of production precision which could be achieved was determined entirely by the state in the art of manufacture of precision machine tools. The Americans had summarised this by regarding manufacturing problems as the barrier to further scientific progress in many fields, particularly in the manipulation and cutting of the new, refractory materials, and they were making resolute attempts to find the answers.

Trouble was an essential catalytic of progress and in the reference to the low sulphur and phosphorus content of Cumberland ore, mentioned in the Paper, it was interesting to note that with the .1% Cr., .25 % Mo. sheet steels which contained sulphur and phosphorus to an extent of .045% that weld micro cracking was responsible, on a certain component, for a reject rate of 25%, until work carried out by Dr. Cottrell of Bristol-Aerojet determined the sulphur and phosphorus content permissible for sound welds in relation to the carbon content of the steel. By reducing the sulphur and phosphorus content to .015% the reject rate fell to 1%. The scrap saved far outweighed in cost any addition in price of the steel.

Insufficient had been done with electronic numerically controlled machine tools to determine the extent of practical application. Their use and economy in prototype application was established and they excelled in producing templates required for large scale application. They could be the means of improving inspection methods but they did not yet improve on the measurement of finite dimensions.

The reference to sintered oxide made interesting reading. Although these had found an application with free machining steels, Dr. Hollis' experience showed that selected grades were superior to the best carbides in machining the range of medium steels. In extending to the ultra high tensile and high nickel-chrome bearing metals, however, the performance over sintered carbon tools appeared to hold no longer and was probably due to the high chrome content of the materials.

Sir Stanley Rawson, in reply, said it would certainly pay Britain to do more development work than to wait for an emergency and then rush it forward. Nothing like enough work was done of the sort being discussed. Although the D.S.I.R. was a splendid institution, it could be improved if more technological aids were brought within its purview.

With regard to the problem of low sulphur and low phosphorus content, at the present time the rarest commodity was the high-class haematite in this country. In order to get the rather critical forgings down to the .025 limit, a great deal of the materials was being melted two or three times to obtain a satisfactory base. It was that lack of satisfactory base which had made the difference between the regularity of low sulphur and low phosphorus content of today, and that of a good many years

ago. One of the points with respect to the very high output of straightforward ordinary steels was that impurities in the steel were very difficult to control. The material required for welding had to be made of a base which itself did not contain more than .02% sulphur and .02% phosphorus. A very hard battle was fought some years ago over the question of steel scrap. It used to be the case that a great deal of the scrap which arose from what was now the pneumatic process was sold at a premium of something of the order of 15% over the ordinary scrap price, and it went into the hearth and electric furnace. But at the present time, the results of using that scrap could just as easily be provided by using old bedsteads. People were driven to re-melting when they should not have to carry out the second process.

As to the question of numerical control, there was still the problem of what in electrical circles was called feedback and in mechanical circles, spring-back.

Professor J. Loxham (*College of Aeronautics, Cranfield*) agreed with the author that it was with the development of power that the machine tool industry started. It was well to realise that in spite of the Boeing 707's and suchlike, the machine tool industry started in Britain and those concerned in it should be proud of their heritage. The steam engine was developed in this country by James Watt, and the formula for steam engine horse power was the mean effective pressure, multiplied by the area over which it acted, multiplied by length of the stroke and number of revolutions divided by 33,000, which gave the horse power. With revolutions of about 12 and mean effective pressure of 15, a computer was not necessary to show that A and L must be large. In the machine tool industry there was nothing more than a treadle lathe, with a cord going round a spindle which was fitted to the wall. That was the machine tool industry. There was a cylinder cast in brass, of 9 ft. length and 28 in. diameter, and instructions were given to bore out the cylinder!

One evening when he was a child he was standing outside the farm where he was born talking to his grandfather, when a motor-car came along the road being towed by one of the farm horses. Every time the car had been out it had been necessary to have it towed home by somebody's horse! His grandfather turned to him and said: "John, one day they will make these work, but there is one thing they will never do. They will never fly." The recent Le Mans motor race was won by a Ferrari at an average speed of 110.6 m.p.h. over 24 hours. Last year an Aston Martin won the race at an average of 112.5 m.p.h. But one wondered whether it was desirable to go any faster than 112.5 m.p.h. as an average for 24 hours. In his view it was not. A student of his aquaintance who was studying at the College of Aeronautics had recently bought a new car, but complained that the thrill of buying a new car had been ruined by the fact that there were so many things wrong with it. In fact, the faults had been listed and they totalled 14, 10 of which were due to bad production engineering. Another 20 m.p.h. on the 112 m.p.h. were not needed. What was wanted was better production engineering, and that was why the Paper presented by Sir Stanley Rawson was so significant and important. It pointed the way to go in the interests of national economy.

Sometimes when he watched telvision he felt like throwing a brick at the screen when he saw people who were trying to boost British industry talking about British craftsmanship, and the picture shown was of an old lathe or potter's wheel. Capital equipment worth about £20 was shown and the commentator said: "This is British craftsmanship". Superimposed on that there were some industries which would spend £20,000 on a machine, and which would then say: "We shall kill this labour trouble with this, because we can stop any man in the street and all he has to do is to press a button and pull a lever." Both those attitudes were wrong. What were neeeded were a £20,000 machine and a man who was proud of it, a man who would nurse and coax it and get the best out of it. In the ideal situation a fitter should have a screwdriver and some spanners. He should not have a file and some emery cloth. It was nonsense to say that high quality parts were very expensive. The material cost the same and the early operations cost the same. The last operation might cost more but not a great deal more.

When he considered the tremendous developments which had taken place in his lifetime, and thought of the kitchen which his own wife had and that of his grandmother in the early days, he could not help feeling that the scientists had made a great contribution in the development of new things, and the phase was now being reached where it was desirable that a great deal of that scientific effort should be directed towards helping the machine tool industry to make their products to a very high standard of perfection. It more young men could be persuaded to come on to the production side, there was enough and more to keep them busy.

Sir Stanley Rawson said he knew of a distinguished American concern which had mechanised so successfully and to such an extent that it had lost its craftsmen. After some time the concern found itself up against a problem which had been present but not quite so obvious, and it was necessary to search for a man who could take the particular machine to pieces and modify it slightly so that it would obviate the problem. There was not a single man in the whole plant who knew enough to take such a complex machine to pieces, make the small modification which was necessary, and put the pieces back so that the machine was as it was before.

Mr. W. J. Morgan (*Machine Tool Trades Association*) said that Sir Stanley Rawson had given a fascinating survey of the development of the machine tool from those early days when its only purpose was to supplement the physical effort and skill of the mechanic using manual implements.

That continued through the stage of the supplanting of the crude machine, which effected that only by supplying power and motion, to the application of the principle of geometric generation of form and metrological control pioneered by Maudesley with the invention of the slide rest and Wilkinson by the constraint of motion of the boring bar. The author had also mentioned the significant stage which emerged in the post-First War years when the machine tool became what he so properly described as "an instrument of production".

The first stage saw the emergence of a separate machine tool industry run by specialists who no longer regarded the machine tool as a side line or casual prop to the production of other machines, but envisaged it as a primary piece of capital equipment, establishing in the United Kingdom the first machine tool industry in the world. That first stage of specialisation, however, only meant that there were firms who concentrated on the manufacture of machine tools for supplying the other makers of other sorts of machine, as a natural development from the period when a machine maker made his machine tool to help him as he went along.

After the First World War, specialisation was carried a stage further and one saw the concentration by firms on one or a limited number of types of machine tool. That had led to some confusion of thought on the part particularly of political critics of the machine tool industry, and the reference so often heard to the existence of too many small firms all thought to be making the same thing. Those concerned knew, of course, that that was not so, with the possible exception of certain sectors. On the whole, that specialisation could only assist in the kind of development which Sir Stanley foresaw and which must constitute the machine tool industry's essential contribution to the future requirements of production engineers. Undoubtedly there must and would be still further specialisation, particularly along the lines foreshadowed by Sir Stanley Rawson and arising from what he called the "dual lines of development".

There would have to be high concentration in the development of one of those dual lines involving the control of the machine, otherwise than by the operator, together with that other aspect of the same thing which involved the simplification of basic elements giving to the machine tool designer and producer a flexibility to meet, even on comparatively small scale demand, the varying requirements of the production engineer without committing him to a rigid system of production which robbed him in his turn of flexibility, inhibiting progress in design of his own product.

It was clear that those lines of development of the future machine tool would call more and more for the scientific approach, involving for the machine tool industry a far greater reliance upon design and production teams of high technological qualifications, and far greater access than had been available in the past to the results of specific research directed especially to machine tool problems.

Thus, the future requirements of the machine tool industry reflected upon some of the larger problems facing us as a nation, the two outstanding ones being a great expansion of technical education with the raising of the status of the highly qualified technician, and the expansion and co-ordination of research facilities.

It was appreciated that it was not sufficient merely to state the necessity for those things. It was gratifying to be able to go further and to say that the machine tool industry of Britain was alive to those problems, and was already taking steps which it was hoped to see rapidly accelerated in both the directions he had mentioned. In the meantime, speaking from two sides of the question at once — as a member of The Institution of Production Engineers and as a representative of the machine tool industry of this country — he was grateful that industry had men of the experience and wisdom of Sir Stanley Rawson who, he felt sure, would never allow those concerned to forget their responsibilities in those matters, nor refrain from urging them to take the proper steps in the direction of the fulfilment of those responsibilities.

Mr. Clausen (*late of the Admiralty*) reminded those present that the machine tool industry went back to Maudesley and to Whitworth. Sir Joseph Whitworth inaugurated the well-known Whitworth Scholarships nearly 100 years ago for the encouragement of technical and scientific education in the engineering industry. Mr. Clausen said he always regarded the machine tool engineer as a basic engineer who had the finest training background possible. The good example set by Sir Joseph Whitworth was not followed until quite recently, and that was probably one of the main reasons why Britain tended to lag behind America and the Continent in the development of machine tools, and precision machine tools in particular. It was only in recent years that the Machine Tool Trades Association had instituted scholarships in postgraduate training.

In his view the present situation of the machine tool industry was not so much the fault of the industry as such as the attitude of educational and scientific bodies towards the work involved in it. He had studied the problem and had been unable to find that bodies such as the Royal Institution or the D.S.I.R. or even the University schools of engineering had, until recent years, paid any attention at all to all to raising the intellectual level and content of the machine tool industry, without which little or no effective progress could be made. The scientific and educational bodies deserved more criticism on that ground than did the machine tool industry itself.

Sir Stanley Rawson, in reply, said that so many things which the institutions were criticised for presented themselves as individual problems, and it was very hard to appreciate when the time arrived that they should be tackled in an organised way. One of the problems which faced the machine tool people was when it became obvious for the first time that one could not afford to heat treat a forging after it has been machined, because of inevitable distortion. That problem had presented itself earlier, principally in the making of gravity pressure die castings, when

instead of tackling the job of cutting the steel in the finished condition, one took the risk of heat treating the die after it had been cut. As an example of what that meant, one very well-known British electrical company ordered two dies, each of which contained steel which was worth £520. The finished two halves of the die were worth just over £9,000, and the top die cracked in the final stages of heat treatment. The result of that was to set in train a certain amount of investigation into how to cope with those materials, and when a 95-ton forging was required, those concerned knew how to cut it. That could not have been done by any amount of education.

Mr. T. B. Worth (*Head of Department of Production Engineering, Birmingham College of Advanced Technology*) suggested that it was as well to stand back from time to time and to see what facilities existed with regard to education and training, and what facilities could be provided specifically to help the machine tool industry.

For some years the Universities had done, and were still doing, excellent work in that respect though on a limited scale. There was also the national Colleges which, again, were doing first-class work. All those contributions must, of course, continue, but there was now an opportunity for the industry to see what could be done through the Colleges of Advanced Technology and the Diploma (sandwich) Courses in Technology which embodied periods in industry. Those might have something important to offer at undergraduate and at postgraduate level. As the author had pointed out, there was not enough being done at the postgraduate level particularly.

Mr. Worth said he was staggered during a recent visit to Delft and Aachen to find how much more work was being done in the machine tool field in the Universities and Colleges there, when compared with Britain. It was not a criticism, but merely a pointer to indicate that industry and all concerned should help by seeing that facilities really existed and were being planned for the future, and used by the industry to the full.

One way in which to create interest was by the establishment of Research Fellowships. At Birmingham College of Advanced Technology several such Fellowships had been created, but not in Machine Tools. Research Fellowships offered first-class opportunities for getting as much activity in research and development as possible by co-operation between industry and education. If that were done, it would be possible to step up the level of research and development at a minimum cost to the industry itself which should take the initiative. Research and development were very costly undertakings, and a survey of what facilities existed and what could be done might be a useful starting point to assist in the higher technological education of people who were going to be concerned with the design and use of machine tools which, as the author had stated, were basic to all manufacturing activities.

Mr. Landon Goodman (*British Electrical Development Association*) said he had heard the comment made that graduates were not worth their salt in industry. If that were true, what was the point of training them? It would be interesting to know whether they were being trained correctly and whether the industry could use them. Perhaps some of those who had said that graduates were no good in industry would say why they were no good. In that connection, it would also be of interest if Mr. Morgan could state how many graduates the machine tool industry was using, how many were being employed in research, how many in development and how many in production. One also would have liked to hear Mr. Morgan state the percentage of the industry's turnover devoted to research, e.g., if the turnover of the industry was, say, £100,000,000 a year, some 2% was allocated for research and development. That would give some idea of what was happening.

Secondly, it would be interesting to know which really new developments in machining had come from the machine tool industry. Ultrasonic and spark machining were two examples which had come from other fields.

It had been said, quite rightly in Mr. Goodman's view, that the basic production processes in industry were very inaccurate, with the result that it was necessary to do a great deal of cutting and carving. If the basic processes were put right there would not be so much cutting to be done. In his view, industry was on the wrong line so far as the machine tool was concerned.

Sir Stanley Rawson, in reply, said that graduates were like everyone else; some were good and some were bad. The sort of graduate who threw his weight about and knew it all would probably not be any good; but the graduate who took the view that he was as good as the next chap would in all probability turn out to be very good. For the first three years of his employment in any stage, the graduate was not as good as the man who had five years behind him, but at the end of five years he was better than that man. Out of 30 graduates in five years whom he had brought into the steel industry, only one failed to make the grade.

The development of spark machining and impulse machining was carried out entirely by the machine tool making industry. It was not the first idea that counted as much as making the thing work. More money had been spent on spark machines than on any other branch of research in the industry.

Mr. W. J. Morgan (*Machine Tool Trades Association*) agreed that the idea was prevalent in Britain, and particularly among production engineers, that those engaged in the industry had a prejudice against the graduate. There was a period when, in order to be able to say that they had had two years in a machine shop, some graduates expected to stand around watching others do the job. That had now

ceased. The graduate was wanted. Not enough graduates were being employed in the machine tool industry.

Reference had been made earlier to the small step which the industry had taken by way of instituting certain scholarships. Arrangements were now being made to appoint an education officer for the Machine Tool Trades Association. It was fully realised that brains were necessary and that they had to be paid for.

It is not for the surgeon to study the metallurgy of his instruments; but once those instruments had been prepared, he had to say whether they were right or wrong, and in using them to make sure that the people who had devised them had made them correctly for this purpose. He would not have expected a machine tool engineer to have devised the electronic control for machine tools, but God help him if he did not use it once it was introduced! Today it seemed that the demarcation between various sections of engineering was becoming more blurred, and it was not enough for a man to be a mechanical engineer. He had to know something about hydraulics and electrical engineering and transmission, to be able to speak the language of the electronics engineer and to call him in to work with him. There had to be a greater appreciation of the part that each could play in the scientific production of machine tools.

Mr. Bolding suggested that there was rather a self-satisfied and smug attitude to be found, on the one hand, among the scientists and, on the other hand, among the production engineers or the machine tool engineers. He had endeavoured to try and bring some of those people together to adopt an attitude which would be productive of something of which those in this country could be proud. The scientists said "This man does not know what he is talking about" when referring to the man in the shop, and the man in the shop said "The scientists have their heads in the clouds. I do not understand them." Then, again, there was a tendency for the machine tool industry to say "Here is a machine; take it or leave it." What was being done by the scientists, the education authorities and the machine tool trade to bring all the different factions into one homogeneous whole which would be worth while?

Sir Stanley Rawson, in reply, said it must be realised that every machine tool, wherever it was made, was a mixture of the traditional and the new, and was produced in response to some specific need. There were people in the machine tool trade who specialised in the highly accurate machine, and it was to be regretted that there were not more of them; but it was all conditional upon demand from outside. Although it was an interesting experiment to build a highly accurate machine, unless the person who asked for it appreciated the reason and the need for it, he was wasting his time and the time of the machine tool maker.

Sir Stanley Rawson receives a silver rose bowl from the President of the Institution, Mr. G. Ronald Pryor.

There were occasions, fortunately not many, when the difference between a particular piece of equipment and another piece of equipment could mean the difference between life and death. There were many engineering firms in this country which differed very greatly. There were many Government institutions whose demands for accuracy were such that they themselves did not quite appreciate them, and sometimes machines of high accuracy were used for purposes which did not require great accuracy.

Mr. B. E. Stokes (*Chairman, Institution's Editorial Committee*) moved that a hearty vote of thanks be accorded to Sir Stanley Rawson for his lucid and very interesting exposition of the factors which determined and influenced machine tool development. Those who had listened to Sir Stanley Rawson were equally grateful for the very fascinating study of the relationships of the factors which he had given, and for pointing out that maintaining the balance between those factors was still very much a matter of human judgment and intuition.

It was clear from the discussion that those present had been mentally stimulated in a variety of directions, and one would hesitate to attempt a summing-up in that respect. They had also been reminded that, as in the use of machine tools, so in development and design the recognition of error was important primarily as a means of knowing where to take positive action.

In proposing the vote of thanks on behalf of those present, it seemed appropriate also to thank Sir Stanley Rawson on behalf of the people who would read his excellent Paper.

The vote of thanks was carried by acclamation, and Sir Stanley Rawson was then presented by the President with a silver rose bowl as a memento of the occasion.

MACHINE TOOL CONTROL SYSTEMS

a symposium organised by The Institution of Production Engineers and held at The College of Aeronautics, Cranfield, as the Tenth Summer School, from 24th - 28th August, 1960

IN welcoming the members of the Symposium at the first session on Wednesday evening, 24th August, **Professor Murphy,** Principal of the College of Aeronautics, said that production engineering had been a subject for study and instruction since the earliest days of the College. Under the leadership of Professor John Loxham it was now going " great guns ", and some evidence of that would be seen during the Symposium, in the form of the new Machine Tool Laboratory where members would be able to see a number of demonstrations.

" Production engineering " said Professor Murphy, " is concerned with the conversion into solid achievement of the principles of engineering science. Therefore, nothing done in this College can come to full fruition unless the lessons of production engineering are brought to bear upon it. This is why increasing importance is being attached to the subject."

Etymologically, he concluded, a Symposium was an occasion for dining, drinking and conversing. He hoped that the College would be able to help suitably with the first two of these activities, and no doubt the members would themselves be able to provide the third. The College warmly welcomed the members of the Symposium, and wished them every success in their proceedings.

The President of the Institution, **Mr. G. Ronald Pryor,** who was in the Chair, thanked Professor Murphy and his colleagues for making the College available for the Tenth Summer School. It was the Institution's first visit to Cranfield, and members would have seen sufficient already to convince them that they could hardly have met in a more suitable place.

The dominant idea behind the Summer Schools had always been to bring together those who taught production engineering and those who practised it. This year there had been a departure from the usual pattern. Hitherto, the two streams had been kept somewhat distinct. There had been parallel discussions and lectures, one section designed for the practitioner and one for the educationist. It had been felt that this had not been altogether a good idea. Accordingly, this year the two groups had been brought together. At the end of the Summer School, those at the Institution's Headquarters would be glad to receive letters indicating how members had found the new arrangements.

The first address was to be given by Dr. Koenigsberger, of the Faculty of Technology of the University of Manchester, on the subject of " Design ". An old friend and member of the Institution, Dr. Koenigsberger needed no introduction. He had taken part in the work of the Institution on many past occasions, particularly the delegation to Delft to meet Continental Professors of Production Engineering.

The second speaker was Mr. Stafford Beer. Though not a member of the Institution, it owed him a great debt, for he had been so kind, on several occasions, as to make immensely interesting contributions to the proceedings. Mr. Pryor added that while he found Mr. Beer's work absolutely fascinating, he never understood what it was all about!

The addresses given by Dr. Koenigsberger and Mr. Beer, which appear on the following pages, were discussed as reported on pages 574 - 577.

The other Papers read at the Symposium, with reports of the discussions, will appear in subsequent issues of " The Production Engineer ".

DESIGN

by Dr. F. KOENIGSBERGER, M.I.Mech.E., M.I.Prod.E.

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THE performance of a machine tool is measured by the quantity and quality of its output and the cost of its operation. It depends upon the type of process carried out by the machine, the quality of its manufacture and the control of its operation.

The machining process determines the general lay-out, the operational movements and the detailed design of the mechanisms for their execution. These must satisfy not only the requirements of the process as such, but also those of the materials of tool and workpiece and of the surface quality which has to be produced.

The qualitative standard to which the machine tool has been manufactured affects directly the quality of workpieces which it produces. Again, both qualitative and quantitative performance are influenced by the performance of the controls, and these may be operated by hand, by mechanical devices or by fully automatic equipment.

Over the past few decades developments of tool materials and cutting processes have resulted in increases in tool life, cutting speeds and feeds, but the relatively recent progress in the field of control has overshadowed these developments. The task of the operator has been eased in the following manner:

1. There has been a reduction in the physical effort required through the mechanisation of operating devices for the setting, cutting and feed movements.

2. Sequences of several single steps of control operations for a particular job involving the setting of speeds and feed rates, of depth of cut, etc., as well as starting and stopping the driving mechanisms, have been replaced by preselected control cycles. The operator selects the required final result and the machine carries out the various operational steps in the necessary sequence.

3. The controls for a given sequence of machining operations have been mechanised, e.g., by means of trip dogs, cams or switches which, once adjusted and set by the operator, initiate the necessary control impulses in the required sequence and at the right time.

4. Equipment has been developed which, from templates, punched cards, magnetic or punched tapes, etc., prepared directly from the drawing, enables the machine to follow instructions without the need for interpretation by the operator.

The means employed for these purposes may be mechanical, hydraulic, pneumatic, electronic, or any combination of these, and the devices used are completely different from those hitherto used in conventional machine tools. It may also be observed that few machine tool designers are conversant with or have experience of the finer points concerning hydraulic, electronic, pneumatic and other controls. As a result, the average machine tool designer is faced with the choice between applying to his machines ready-made control devices obtained from specialists or of undertaking design problems in a field in which he has little or no experience. In the first instance, the machine tool and the control device may not be suited to each other and anything but reasonable efficiency will result from the combination; in the second, the designer has to work his way through unfamiliar problems and to spend considerable time not only in gathering information and experience but also in discovering and overcoming difficulties which the specialist has encountered and long ago mastered.

If, in addition, one considers the fact that even on development work in a familiar field a designer not only has to solve functional problems but also to study questions of competitive design and economical production, progress is bound to be, to say the least, embarrassingly slow if at all possible.

The machine tool designer will, therefore, find it highly advisable to enlist the help of specialists despite the fact that they may not necessarily have much knowledge and experience in the machine tool field.

On the other hand, the eventual performance of the machine tool is the final criterion for the success of the complete design, and for this reason, the parameters of machining accuracy, of quality of the machined surfaces, of output and of cost of operation must still form the basis of the design. These remain the machine tool designer's province, and he must therefore not only correlate the efforts of the control engineer and his own but also be able to make any final decisions which are required whenever a compromise solution is unavoidable. The machine tool designer can only do this effectively if he is able to appreciate the basic requirements and principles of the work for which he obtains the collaboration of the specialist.

As the order of magnitude of operational speeds of cutting forces and of rates of metal removal are much lower in hand-controlled operations than in automatic processes, it has not been so strikingly evident in the past that similar considerations apply in the design of devices for manual settings and controls. Here again, the need for easy understanding and relatively foolproof manipulation requires a sound application of scientific principles, covering matters as widely different as elementary mechanics, industrial psychology and ergonomics.

The functions of control equipment for machine tools are mainly concerned with :

1. handling workpieces;
2. positioning tool and workpiece carriers;
3. starting, stopping and reversing operational movements;
4. inspecting finished articles, resulting in either :
   (a) faulty parts being rejected and the machine being stopped in order to enable the operator to re-set it, or
   (b) the operation being repeated until the result is correct, or
   (c) the workpiece dimensions being continuously checked and the settings corrected, if necessary, during the operation.

The designer has to analyse these functions and to develop equipment for producing and transmitting :

1. the signals initiating and stopping the operation; and
2. the energy required for executing the operation.

In the case of a machine tool having purely manual controls, the operator will give the signals and also provide the energy for the control operations. In a mechanised type of control the signals will again come from the operator who moves levers or presses buttons, through which the energy will be provided by the machine. In a fully mechanised machine, the sequence of the signals is pre-set and the control energy provided by the machine. In a truly automatic machine signals and energy are again provided by the machine, but here the signals are based not only on the original programme fed into the control device but also on the results of the measuring, resetting and correcting operations carried out by the control equipment once the work has been started.

The requirements of the control operations not only form the basis of the design specification for the control equipment, but also affect the design of the machine as a whole. Thus neither the control engineer, the communication engineer nor the expert in hydraulics, pneumatics or electronics can succeed unless the machine tool designer contributes his share by suitably co-ordinating their work and by applying it to the specific duty required for the machine.

In the case of automatic controls the whole machine tool becomes part of a servomechanism and has to be designed as such. Due regard has to be paid to the effects of cutting and friction resistances, of forces which depend upon the required accelerations (masses) and the working speeds (friction), damping effects and deformations of the elements of control and driving mechanisms (screws, hydraulic cylinders, piston rods, oil columns, etc.), caused by the working load. Whilst high degrees of stiffness and small moving masses are often important from the point of view of quality performance of the machine, they may become even more essential when the requirements of the servo-performance are considered.

Unless the machine tool designer learns to think in the terms of the control engineer, to appreciate his requirements, and either to satisfy these or give due warning in good time when these requirements cannot be satisfied, he will not be able to produce designs which will make full use of the facilities and possibilities offered by modern devices.

The opinion is often expressed that designers are born, that design work is an art and largely a matter of intuition backed by experience and that it cannot be learned by systematic study. It cannot be denied that a certain aptitude mixed with a considerable amount of enthusiasm is necessary to become a successful designer, but does not that also apply to other occupations and professions ? The most ingenious work of the gifted designer is, however, doomed to failure if it is not based on a sound application of technical fundamentals.

To think of successful or brilliant designers in terms of inventors who are only full of original ideas is a fallacy to which Thomas A. Edison referred when he stated that he attributed his success to 5% inspiration and 95% perspiration.

The need for the ability to create technically sound designs rather than merely to invent functional mechanisms and devices has perhaps been best expressed by the founder of the Krupp organisation, whose statement may be very freely translated as follows :

> " Technically sound work can easily lead a good designer from the slums to Mayfair. The mere inventor who is not a sound designer, on the other hand, may well finish in the slums even if he has started in Mayfair."

OVERALL CONTROL

by STAFFORD BEER

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THE job of control is the task of management. A Paper ought to begin with a resounding assertion, even if it is a thumping platitude. Here is another. The days of the omniscient gaffer are past, and control has to be delegated and diversified. May we have one more ? The designer of a control system is not necessarily or even desirably a manager. These three amiable statements are not at all controversial, as far as I can see. Yet the consequences that flow from them jointly are intolerable.

By this I mean that industry cannot contain for very much longer the outcome of the advancing technology of control within its traditional organisational stereotype. If this assertion is to be made good, and if any light is to be thrown on the problems of overall control that now confront industry, this stereotype must first be examined.

First of all, we have a breakdown of the running of a business into major activities, such as manufacturing, sales and finance. Here begins the delegation and diversification of control. These branching processes continue. Manufacturing is divided into production and service departments, and these in turn into simpler units : machine centres, stores, and stockyards. Sales is divided into product groups, geographic areas, large and small customers, contracts and jobbing work, for example. Finance is divided by the legal requirements of raising capital and financial accounting on the one hand, and the more pragmatic object of management accounting and costing on the other. This is a brief and loose description : its aim is merely to set the scene.

Secondly, the kind of control that is exerted over all this is essentially *social*. For the organisation of the management task concerns people at every level. There is the stereotype of the managing director, powerful and remote; the stereotypes of the three directors of whom I have chosen to speak, and of their underlings — down to the charge-hand who knows his machines with a nearly human intimacy, the salesman whose little area of the order book is an empire charted and administered with humanity, and the cost clerk who has an intuitive nose for the off-standard process. From top to bottom they are cartoon characters. And this means no disrespect : it means that we abstract from our experience a host of over-simplified caricatures, draw boxes round them, and call this " the organisation ". There the neat two-dimensioned picture sits in everybody's mental drawer : the pyramidal hierarchy of people, the family tree.

the social control system

In doing this, we very nearly forget what it is that makes this management machinery actually work — for it is nowhere shown on the chart. It is the social control system; it is the dynamic, richly interconnected, indefinable pattern of communication, modification, adjustment, coalition, and every other form of interaction between men, that coheres any society into an organised whole. For the control system is built entirely of living parts, to each of whom the facts of the external world become meaningful only in terms of other living parts. The action taken, the decision given — these things are based on a kind of triangulation procedure in which the point at issue is isolated and recognised by the conflux of responses given in personal relationships.

The commercial manager did not see what the production disaster actually was, nor the resulting aborted product; nor is he working on scientific reports of these matters. But he was told of the incident at lunch by his production colleague; the inspector has made some pithy comment on the telephone; the cost office has explained the implications of selling the result as one of a number of possible alternatives each with its own standard cost; and a customer is negotiating to buy something that he fully understands to be quite unlike the specification written down on all the bits of paper. In the outcome, everyone is happy, and profitably so, with a conclusion reached on some extremely shaky information — information that had to do with figures, with value judgments, with guesswork, with experience, with a knowledge of other people and their tones of voice.

what really matters

All this sounds as if I am pretending to have discovered what actually goes on in industry, while everyone else is fooled into believing the formal

accounts given in textbooks. Not so : everyone knows that no system is perfect, and that real life does not conform to the idealisation in terms of which it is convenient to think. But this is not the point at all. My contention is that we have got hold of the wrong idealisation anyway. What I have said is not a joke about endearing nonsense masquerading as efficiency : it is meant to be an account of what really matters in overall control. Let us try to make this more precise.

We know scientifically (from the Theory of Games) what is involved in seeking an optimal strategy : that is, for example, a policy for a given situation that will yield the highest pay-off after the risks inherent in the situation have been minimised. Given a complete set of facts, the choice of the policy can be uniquely determined; otherwise not. But we know that real managerial problems do not come with "full instructions", and therefore that straightforward computation procedures are inadequate to their solution. So it is not possible to pretend that the installation of sufficiently massive data-processing equipment will eventually reduce all management problems to solvable mathematical puzzles.

Again, we know scientifically (from information theory) that the degree of control that can be exerted over a system is proportional to the logarithm of the amount of information in the system. In particular, some managers attempt directly to monitor the output of their organisations, the input to which is the activity of a large number of people, with a view to picking up and eliminating errors. This is a mathematical impossibility (it follows from Shannon's tenth theorem). It is essential that the whole social structure that generates the output of an organisation be deployed to monitor it. Industrial organisations work because they obey this law; people escape from seemingly inviolable prisoner-of-war camps because their guards cannot invoke it. So no one ought to make deprecating noises about so-called "unofficial" channels of communication in the social group : they are not only psychologically useful but *mathematically vital* to its effectiveness. And it is not possible to pretend that the attenuated information pathways at the top of an organisational pyramid, whether this is a hierarchy of managers *or* data-processing equipment, have adequate channel capacity for controlling the whole system. They have not.

Finally, we have to recognise that an automatic control system constructed as a computerised artefact of an organisation chart will not actually work. This is because the interconnectivity, the feedback, and (in general) the *self-organising properties* that make the existing social control system viable are simply not given in the circuit diagram of the chart. This we also know, and can formulate and quantify, scientifically (from the science of cybernetics). For it is now understood that in a free-running system with a structure that is not fully determined, containing information links that are probabilistic as well as " noisy ", the *identification* of the commodity to be controlled is impossible. The system cannot therefore be designed as a servomechanism, nor can it be controlled by a finite number of predetermined control loops.

An exemplar of such a system is given by 15 men in red jerseys running about on a field according to the rules of Rugby football. Here there is a general but unpredictable pattern of behaviour; a certain order is detectable, but the structure itself flows. This system is generating information about itself at a great rate; it manifests high " variety ". It can only be controlled by a system of equivalent variety (this was rigorously demonstrated by Ashby in his law of requisite variety). Now this control variety could conceivably be obtained by wiring up the brains of each of the 15 players to an electronic computer, which would then predict the behaviour of the whole system and permit the exercise of control. The alternative is to install another system capable of generating an equivalent variety, such as 15 men in white jerseys.

The analogy I have just drawn must not be pursued too far, but its key features exemplify the cybernetic principles of control for large, probabilistic systems. Proliferating variety is not to be cut down by error-controlled feedback; it is to be absorbed as blotting paper absorbs ink — a process which involves the mirror image of the wet writing : its every dot, dash and flourish. And there must be intimate connectivity between the control and the controlled, at all levels, and in every direction at once. In fact, we are left with one large, organic, self-organising, system. For one of the subtle features of a large complex system that is in fact in control, is that it is not at all clear what parts are controlling and what parts are controlled. The equivalence of variety theorem means that half the total system is monitoring the other half : the two halves intimately interact, and do not even retain their respective identities as time goes by. An organic system (such as the human body or the country's economy) attests to the truth of this picture. The trouble with much of the work done on overall controls for industry is that these facts are not acknowledged at all.

what is the underlying nature of the problem ?

Let us now return to the general discussion : although it is interesting to have demonstrated that arguments in the area of management " theory " do not have to rely, as they usually do rely, on authoritative assertions — the didactic jelly can be fitted with scientific backbone.

Return then to the stereotype of the current industrial control system; and see what happens when automatic control techniques are applied, as they are being applied, at the base of the hierarchical pyramid. It has been widely held that this move towards automation is a revolution : but the reasons usually given are not the important ones.

For this is what happens. In the manufacturing division computer-controlled machine tools are installed. In the sales division incoming orders are punched on to cards or tape, and a computer programme is written to construct therefrom a schedule of production. In the finance division results are

fed into data-processing machines which compute payrolls and costings. We know this is progress. We know this is making things more efficient, quicker, and (we hope) cheaper. We know this is sensational, and that before anyone can turn round we shall be up to our ears in the problem of redundancy. So we write profound prophetic articles on the social consequences of automation.

But never mind the consequences for society outside the company. What happens to the social control system inside, the one of which we spoke before ? What we are doing in terms of overall control, in terms of the function that we said was the task of management, is taking decisions by machine. They are minor decisions; they are decisions within the competence of a machine to take, because management has specified the rules the computers will use. But the rot has set in. For now *there is no access to the processes of decision*; only the decisions themselves emerge. We have started to build the pyramidal hierarchy of non-interacting elements that we know cannot work.

a matter of urgency

It is in my judgment a desperately urgent matter that we escape from the organisational stereotype that only works because it is not true, before we have recreated it in steel, glass and germanium — without its social relationships.

Consider in more detail the example we have been discussing. At least two schedules must be forthcoming from each of the three divisions. Manufacturing prepares schedules of stocks (raw materials and engineering spares) and of machine availability (involving manpower and preventive maintenance). Sales prepares schedules of orders-on-hand (by various criteria) and of delivery priorities (which may not be consistent with any set of rules). Finance prepares schedules of costs (machine/hour rates, yields, overheads) and of wages (which depend on payment systems, bonus incentives, and so on). Each of these six operations can be undertaken by automatic methods, on decision-rule computers which would separately produce a locally optimal conclusion. According to the hierarchical model, then, a next-higher-level computer could take these results, and produce in turn the optimal production control strategy. Such a control system disregards every principle in the book. We may examine an example of the disastrous results in order to observe the mechanism.

An array of production machines has a time-dependent set of capacities : today's capability for this shop depends on the state of the machinery, its manning, its maintenance. The structure of the order-book is also time-dependent; what is not on order today may be on order tomorrow, and what was not urgent yesterday may be promised today for immediate delivery. The basic problem is to match the variety of the production capability with the variety of the market potentiality — under the constraint of minimising cost. But the costing situation is also time-dependent (or ought to be), for minimal costs depend both on the use of preferred process routes, raw materials, and manning schemes, and also on particular balances of orders showing particular profitabilities. There are opportunity costs associated with not manufacturing something that could be manufactured; there are potential machine breakdowns implicit in certain solutions to the programming problems; there are issues of commercial goodwill involved in sacrificing one delivery to another; and so on indefinitely. Each of the six schedules, which has a local optimum, has associated with it utilities for the *whole* organism which cannot be assessed independently of the factors which contribute to the local optima of the other five.

Without automation at the six stations, there is already a tremendous loss of efficiency and profit involved in the diversification of these control functions. This loss is mitigated, however, by the social control system, whereby those concerned in the six functions are in constant personal contact. In fact, in a well-run factory, none of the six schedules is fixed in complete isolation from the contemporary state of affairs affecting the other five schedules. But the minute automation is introduced, this system is shattered. What it comes to is this : we *cannot* break up the decision-taking process into " atomic " decisions (of the form : *if x do y*) that can be taken on data-processing equipment. For to isolate decisions in sets of binary outcomes is to make them trivial : it can only be done for problems with complete information and a unique outcome (such as are found in logic with strings of syllogisms or Boolean algebras), and we saw earlier that managerial problems are not of this kind.

the obvious escape

The obvious escape now is to devise an integrated control system, capable of operating over the whole area. Feed everything into one box that has access to all the facts and then solve, one might argue. But first there is the practical (and very real) difficulty that this answer runs counter to the organisational stereotype. Each of the three divisions (aptly so called) has developed its own automatic machinery for (what it fondly imagines to be) its own " special " purposes. And it is of little use in practice to reason that the changing technology of control demands a change in the organisational stereotype, when the reply that " the company works like this " is irrefutable. But apart from this snag, we are not much better off scientifically. For we are still confronted with " a game with incomplete information " : the integrated control box could compute many (I think an infinite number of) feasible solutions — but no best policy would emerge. It is *a fortiori* the case at this higher level that data-processing cannot cope with a non-trivial decision.

The discussion is now in a dreadful muddle, and has reached an impasse. The even worse fact is that, in my submission, this is precisely the muddle and the impasse at which we have actually arrived in real life.

some suggestions about the answers

We shall have to go back again, and seize firm hold on one highly significant fact. The pre-automation system, the one with the intricate social control, actually works — at least fairly well. Why ?

The answer is not that it is fully decentralised, as the newer systems tend to be because of the highly specialised automation equipment that is coming into each division. It is not that it is fully centralised, as arguments from "making use of all the facts" tend to make it (compare the nationalised industries). In fact, the concepts of centralisation and decentralisation constitute a false dichotomy; they emerge from studying organisational stereotypes and the charts depicting them, instead of from studying real and viable systems. The stereotype for *these* is a living organism.

In a living organism we find the self-organising system *par excellence*. There are divisions, yes. There are limbs and livers and kidneys. There are divisions in the control system, too. There are nervous, chemical and mechanical controls. Some functions (such as heart beats) and some controls (such as unconditioned reflexes) are autonomous, yes. But no function and no control system is independent of every other. It is this complex of interacting systems, subsystems and component parts that cyberneticians have studied, and from which the formal principles they have elaborated are drawn. It does not take much imagination to see that the way a factory operates fits this organic model fairly well : there are divisions of function and control, but a rich intermingling through the social control system nonetheless. But it seems that imagination *is* required to acknowledge what is important about the analogy; and we might do better to work from the pure cybernetic theory which underlies the efficient operation of both the organism and the factory.

There is no doubt, I therefore suggest, that the study of technique in each of the stereotyped divisions of industry has gone much too far in isolation from the rest. The production man has concerned himself with perfecting manufacturing practice and its automatic accomplishment, and has left its maintenance, manning, costing and product selling to others : "that's not my job". Or, in fairness to the poor man, if he ever has tried to involve himself in these other functions, the engineer, labour expert, accountant and salesman have very quickly told *him* whose job it was. The same is true for the others. It has all been done with complete propriety, on the theory of the division of labour. But in the outcome, the company that is supposed to be an integrated organism has been exploded like an engineering drawing. There are times when we get an uneasy feeling about this disintegration, as we might if an anatomist showed us a thousand bottles of spirit each containing a human organ and declared "this collection is a man". But we put this lack of integration down to human nature, and form another committee to bring things together again.

A good example of the difficulty is indeed production control. This activity had hardly been heard of until companies grew, and specialisation developed, to the point where an integrating job simply had to be done. But this activity itself does not fit the organisational stereotype. For a start, no one knows to whom it should report : we all know factories in which it is responsible to sales, to production, or to finance — or for that matter to engineering. Next, almost everyone is agreed that it must be frightfully simple : "we want no colossal, involved, expensive, bureaucratic, or any other pejorative adjective, system here". But what about the law of requisite variety ? How can there be a system of control so simple that "it cannot go wrong", if it is not detailed and selective enough ever to go right ? Most people are vaguely aware, even as they say these things, that tremendous variety has to be generated if real control is to be exerted; and also that the tendency for production control departments to grow to massive proportions is not just due to empire building. One distinguished industrialist recently displayed this dual unease very delicately with the comment "The great danger of such a (production control) department is that when striving to improve the control, undue complications may set in".

If we tried to make a workable man out of a collection of the human organs by imposing a control system on them, we should doubtless hope for a simple system, and doubtless find that we had invented an impossibly involved one. People should be warned against trying it : undue complications may set in.

a definition of overall control

The fact is that overall control systems are simply not isolated departments, nor organs, nor structures, nor procedures. They do not really exist as entities at all. (I say this with the wisdom or folly of one who has been devising them for the last 12 years.) An overall control is a manifestation of the organic interaction of many recognisably different but funtionally indivisible parts. To design an overall control is not to set up the world's biggest computer; it is to relate activities with each other so that they automatically *modify* each other. It cannot be done on the hierarchical model, because there is no access to the internal decision processes of each activity. It cannot be done by "good management" nor "adequate consultation", because there is not enough channel capacity in the managerial hierarchy, and there is not requisite variety in the consultative committee structure. It has to be done by organic design, so that the whole organism is a self-organising system. Animals do it; the scientific principles (some of them at least) have been discovered; and pre-automation companies, using a social control system, exemplify it.

The whole challenge is therefore as follows. Are we going to use these scientific principles to recreate this organic answer, now that the advent of specialised automation is wrecking that social control ? I have saved until last the main reason why we must. It is not only the function of an organic self-organising

system to control — in the sense of holding down wild behaviour, or keeping variables within physiological limits, or even of making operations profitable. This is the *only* kind of system that has the formal properties of learning, of adapting, of evolving — in other words of surviving in a changing environment.

what then can be done ?

The environment *is* changing — fast. I do not consider that the challenge I have outlined can be met unless the organisational stereotype is consciously changing too. Attention must be paid to the way organisations *really* work, and research ought to be expended on finding a better model of the organisation than the hierarchical " family tree ". Next, it is time to abandon as inadequate to the new control technology a stereotype which relies on an arbitrary and sporadic committee system to integrate the advancing specialisms. To " spare an afternoon a month (other engagements permitting) " is a hopeless approach to the intense interdisciplinary activity that is now needed. Every specialism in the company should hive off a man (preferably its best man), who would, of course, have to be replaced, full-time, to form a department which would permanently study the overall control problem of the company in the light of this rapidly advancing control technology. To this team would be added scientists competent to study the also advancing theoretical work in cybernetics itself. Such a department would inevitably report directly to the senior executive. (Incidentally, for those who have always wondered what an operational research department is supposed to be, I have just defined one.)

With an organisation of this kind, fully integrated with the existing management structure, it might be possible to build a synthesising activity into the collection of specialisms which now diversely control the destiny of industrial companies. I think this is a good idea, whether we are talking in terms of introducing control machinery or not. But in the context of the advanced mechanisation of so many functions at the base of the hierarchy of management, I think a development of this kind is absolutely necessary. Let me repeat the reason : it is not simply that all these new techniques need understanding and " keeping in touch " with each other; it is that they must be designed into an overall control system capable of replacing the one that their introduction is unwittingly destroying — while we have our heads buried in boxes of electronics.

Can we foresee at all what the resulting system of overall control might look like ? There is a number of clues. In the first place, it is not at all likely that we want huge machines disgorging masses of figures. For no one really needs all this data. The control system itself needs the data, and will reabsorb them in the process of seeking equilibrial solutions to problems of disequilibrium. The information printed out for management purposes will be sparse. It will concern two things : strangeness, and ethics.

" Strangeness " I define as perception which does not fit the pattern of experience built up in the control system. One can, for simplicity, regard this as analogous to statistical quality control : the system is to bring to the attention of management incidents and outcomes which are *improbable*. Managers need to reflect on strangeness in the operations for which they are responsible : they do not need to concern themselves with a great mass of routine trivialities any longer, for these are the very things that the new control techniques handle with ease. Ethical outputs from the control systems are those problems of policy which the machinery cannot resolve because they depend on managerial judgments of what is right or reasonable or fair. It will be a long time before we construct machines with a built-in morality; but I do not think it will prove difficult to construct a control system capable of *identifying* such issues, and printing out requests for a decision.

Next, I do not think that future systems of overall control will find it meaningful to distinguish between the functional activities of the company as we know them today. Judgments of the form : " This policy meets our production situation, and the sales people are content to let it go, but it is not a very good bet from the cost point of view ", will be meaningless. No course of action will count as a policy at all which is not indivisibly practical-commercial-economically oriented at the same time. Hills are climbed by what is continuously " the best route ", and not by resolving possible forward, sideways, and upward leaps.

But we ought to resist the temptation to go on guessing about the future of overall control systems, abdicating the role of prophet to accept the onus of action. The only difficulty is that the right context must be provided before results can be obtained. If control systems that cut across existing organisational stereotypes are the right answer, then there is no point in trying to do the job on the shop-floor, or in the cost office, or anywhere else, " first ". It is dangerous. It is the wrong job.

And so we must continue to advocate a new look at the whole beast before we go too far in doctoring its component parts. Heaven help the patient with a stiff arm who is treated with a liniment for a muscular disorder by an " arm specialist ", if the real cause of his stiff arm happens to be trouble with his heart.

Overall control, it rather surprisingly turns out, means exactly what it says.

DISCUSSION

Mr. M. Seaman, opening the discussion, asked to be forgiven for linking Dr. Koenigsberger and Mr. Beer in what he had to say. He recalled having been, at the meeting of the Organising Committee, responsible for the use of the phrase "Overall Control", and he was glad of the explosion which had resulted from it this evening.

Dr. Koenigsberger, by way of forward thinking, had regarded the combination of the machine which manufactured the item and the control which went with it as being of importance, but he had not added something that had come to the forefront in recent years — the design concept of the product, which was very much inter-related with the machine and its control. For instance, certain shape controls were required in machine tools and manufacturing apparatus, as also were self-inspection controls. The discipline of the designer could be wedded to the machine that he was to use. It was a matter of looking at the way that the designer designed the product in terms of the machine. He would like Dr. Koenigsberger's views on this, for it was not simply academic — rather a real issue.

Herein lay his reason for "wedding" the two speakers. It was just the sort of model that, behind his badinage, Mr. Beer was propounding. It was tremendously important. They had all lived in a world where, so far as management was concerned, there was not a model which corresponded with that of the human-being who actually operated the management structure. This was very much the basis of Mr. Beer's thesis. If the true concept of control and organisation was the combination of design in the product as well as design and control in the means of manufacture, it represented a very substantial part of the total model. He wondered whether, to put it simply, it was not true to say that the task before them on the management side was to establish a similar sort of total model there. This had been done in certain cases.

It had been perhaps popular to look askance at those struggling little men who had grappled with computers and organisations, but he knew from his own observations that many of them had taken the view that it was the design of the organisation that was fundamental and must be resolved before one could exercise control in the overall sense.

Specifically, then, he would ask Dr. Koenigsberger: was design of the product not a fundamental part of this total picture of design? If this were so, he would ask Mr. Beer whether it did not now follow that there was now a very important model of organisation, which was important to many of them, and which they had practised, emerging from his point of view. Did not this little point on design help to establish the model on both sides of the house?

Dr. Koenigsberger replied that he certainly appreciated the problem that existed. It was, however, perhaps a matter of the chicken and the egg, in that there was an inter-relation between the design of the machine which produced the product and that of the product itself. As Mr. Seaman no doubt knew, they were working in Manchester on the development of devices for machine tools with which greater accuracies than were normally possible could be obtained, with standard machine tools for general purposes. In other words they were not thinking (nor had Mr. Seaman) of a machine specifically designed for a single purpose.

The average machine tool produced components with an accuracy of the order of half-a-thousandth of an inch. Why was it necessary to develop machine tools which were capable of working to an accuracy of a tenth of a thousandth, if no one wanted this? The immediate answer, he felt, was that although this high degree of accuracy was desirable, no designer would ask for it, if he knew that it was not obtainable with a standard machine.

The designer of the product had to take account of the means available for it in manufacture; but in the development of machine tools, and the design of mechanisms, one had to provide new means which would enable the designers to get closer and closer to the ideal of optimal functional design with the optimal possibility of production. This was why he had concentrated on the design of the machine tool.

Mr. Beer accepted what Mr. Seaman said, as far as it went, but did not see why one should stop there rather than somewhere else. He admitted that a tendency to enlarge the frame of reference was growing, but what of the aspects of the overall control problem that were still left out? Dr. Koenigsberger had appealed for more accuracy. An overall control machine that he had been operating had stopped because a card would not go through it. He had allowed for a thickness which ran to four decimal places but the order had specified seven. On inquiry it had been revealed that the person working out the overall dimension (which was in respect of a toy spring) had got that right, but had had a calculating machine with seven places on it! Clearly, all these things had to be meshed.

If Mr. Seaman's point was right and one brought in what he suggested, where did one stop? Everything might be brought in, until the system seized up and it was necessary to say: "We cannot run the universe from a subordinate position". His appeal was for research into an appropriate organisation — neither the decentralised kind which now existed nor the totally centralised one, which was the drawback of the sort of development which Mr. Seaman was describing — rather a new organisation altogether.

Mr. J. M. Jotcham (*S. Smith & Sons (England) Ltd.*) asked how Mr. Beer believed that a purely logical machine would produce his unique answers

without 100% information? Was it not true that many of the human processes referred to were decision-taking processes, which did not involve purely logical routines? At the root of his difficulty seemed to be the fact that he had subjective factors which he had to endeavour to integrate into his model.

Mr. Beer replied that the kind of machine with which one could solve the problem was not an entirely logical one in the sense of being a digital computer. The whole essence of such a machine was that it could learn. That was how humans carried out the process. They learned, they extrapolated, they focused, with the aid of various past experiences, on a new experience and made a forecast about it. One could do it on the basis of another kind of model altogether — not like the flow diagram of a digital computer programme but on the basis of conditional probability, a model in which one built up experiences and used them in this way.

Mr. Jotcham said that the problem was indeed how one was to build such a machine. Surely many of the problems of management were decision-taking problems where the bases of decision contained subjective factors. For instance, there might be three possible courses in a given situation. Logical connections, whereby the courses of action might be compared, may be far from complete, and the course adopted may be chosen because someone had said : " I happen to like it that way."

Mr. Beer replied that the notion of pure subjectivity was out-of-date. A machine in the brain would, in the circumstances mentioned, have said "This will be the way we will do it", and there would be a neurophysiological reason for it, if only a kind of internal penny-tossing. One could design a machine perhaps that could do these things. There was already a learning machine on the market, so it was not altogether impossible.

Mr. J. A. Sargrove (*Automation Consultants and Associates Ltd.*) said that both gentlemen had highlighted the need for a computer which could deal with the inter-relation of many things happening simultaneously. He felt that the kind of machine that would satisfy Mr. Beer's requirements would be something like a machine tool with automatic controls. He would emphasise that no machine tool control was a single system; it was many systems working in parallel. It resembled much more an analogue computer. There was continuous variation of many factors. He believed that the human brain worked in this fashion and not serially as a digital computer.

Absolute accounting accuracy was not needed for engineering decisions, or for management decisions. For instance, it was lunacy to work out in the nation's budget, calculations to the ninth and tenth decimal place. Results to four places of significant numbers would be quite enough. An analogue computer could easily give decisions which were accurate to only two decimal places, but these are made simultaneously in real time. One could easily have 50 - 100 parallel results and these could be correlated. Perhaps more study ought to be made with a view to introducing the analogue computer into the management field.

Mr. Beer agreed with Mr. Sargrove's contention concerning serial operation, and said that the brain could do things that present-day computers could not do because of its parallel operation, and because it used a many-valued rather than a binary logic.

Mr. D. Blakesley (*Head of Mechanical Development Department, G.E.C. Applied Electronics Laboratories*) said that Dr. Koenigsberger had made a point that the control system and the machine tool should be designed as an integrated unit. While he agreed that this was an ideal state of affairs, he would agree also that the control usually was an exceedingly expensive piece of apparatus to develop. So that, unless the machine tool which one was considering had a considerable market, it might well be uneconomic to design a control system specifically for it.

He thought Dr. Koenigsberger had made out a very good case for an off-the-shelf control in certain applications, notably co-ordinate setting. These systems could then be tailored or developed to suit the particular machine. He thought the speaker had gone a little far in suggesting that one ought to develop the two systems, each for the other.

Dr. Koenigsberger, while agreeing with Mr. Blakesley, said that he should perhaps correct a misunderstanding. He had not suggested that one should design a special machine tool control system for every possible machine tool, just as one would not design a separate lead screw for every lathe. He had intended to speak more generally and suggest that the machine tool and the control system should be designed together; that the designer of a control system should not say : " I have never seen a machine tool and I do not want to." The same applied to the designer of the machine tool. He would say that a machine tool control system must be designed with the requirements of machine tools in mind and *vice versa*. One could then have a series of control systems on-the-shelf for various applications.

Similarly, the work at Manchester, mentioned earlier, was concerned with elements of machine tools and would be applicable not to one particular type but to lathes, milling machines, borers and so on. They were designed with all the requirements of control systems in mind. Simultaneously, control systems were being developed with the requirements of machine tools in mind.

The economics of the matter were certainly important. Everyone agreed that things had to be designed and must not simply happen; that there must be a logical and systematic approach and not one based on guesswork.

Sir Walter Puckey said that he might perhaps be pardoned for suggesting that Dr. Koenigsberger's remarks had borne little relationship to his Paper. They had had from him two lectures, both interesting. One comment in particular seemed to provide a link with what Mr. Beer had said. It was that by taking an inferior machine and adding to it a superior control system, one got better results than could be

produced by the machine itself. There was a link here with Mr. Beer's rather scathing reference to systems of organisation. Mr. Beer had claimed that a levelled outlook was present in a large section of industry, and he wondered whether Mr. Beer was up-to-date on such matters.

Perhaps Mr. Beer should have called his Paper "Confessions of a Cybernetics Addict" because he had retreated somewhat from some of the noble thoughts that, as a cybernetician, he had pronounced in the past. He hastened to add that he had a great regard for Mr. Beer and his whole approach to these matters, but it had been worrying to encounter such an old-fashioned attitude, in such a new-fashioned man, towards this subject of organisation. Mr. Beer had constantly used the term "family tree", perhaps because usually half the people on it were dead. One gained the impression that he had been up in the clouds of cybernetics and had not realised that one did not use this term when speaking of modern organisation. One might speak of the "organisation structure" or the "organisation chart" — and certainly there was much confusion about what terms to use — but one aspect of organisation which concerned technologists and managers very much was how to get more out of the organisation than seemed possible by the grouping of the individuals in it. Could one have a control system which produced more than the basic worth of the group itself? He thought one could, and that it might be summed up in the term "wholism".

Some people believed that the total value of an organisation should be greater than the sum of the individuals in it. Usually, however, it was less and the problem was to see that, by organisation, whether applied to the overall concept of the machine tool or the managerial structure, one got more.

He would entirely agree with Mr. Beer's general remarks on the remoteness of achieving overall control in the automative or electronic sense. That was still a long way off, and would probably never be attained. It was a matter of replacing people's names on the organisation chart with black boxes, and this was not yet in sight, although it offered interesting organisational possibilities. Mr. Beer had been a little harsh in suggesting that it was wrong to develop production control systems organised on the basis of computers and the like. It was surely a good thing to see such people as the accountant, the sales manager and the works manager developing new varying means of control, according to the particular organisation. It was all part of the growing process, it was surely a service to long-term more comprehensive development to put into practice "small" concepts of automation or control.

To return to the overall concept of organisation and Mr. Beer's views of the whole *versus* the parts, he was not quite sure whether Mr. Beer had finally come down on the side of the whole, or of the parts. One might assume that control must develop into overall control and that therefore the cybernetic way to look at anything was to look at it wholly. It was interesting to look at the history of the medical profession and the engineering profession in this connection. In medicine all the real progress over the last century or so had been made by looking at the parts — heart, lungs, liver and so on — and having specialists concentrate on these. More recently, attention had been directed to the whole body, the whole personality. In production engineering they had begun by looking at the tool, then the machine, then the gap between the machines, and then automation, the concept of the automatic factory, and overall control.

It seemed to him that though many today were looking at the overall concept — whether in Dr. Koenigsberger's concept of control and machine being integrated, or in the cybernetic sense the whole concept — we must continue to look at the parts, and make progress along individual, small lines — with production control systems, and with automation and control in the limited sense. Mr. Beer seemed to say that one could only look at the whole and that contributions along the lines of the smaller, specialist developments were spurious. He could not agree with that if, in fact, Mr. Beer really meant it.

Dr. Koenigsberger said that he was something of a coward in that he hesitated to cross swords with Sir Walter, lest he should find himself quoted as an example in the next of that gentleman's excellent Papers.

He had not intended to imply that inferior machines with superior controls could produce superior goods. He had had in mind a logical distribution of duties in that a machine might be superior in certain respects in which it *had* to be superior, yet contain inferiorities which could not be economically overcome. A control system could make up for the shortcomings of the latter. If one wanted, say, accuracy and speed, one could produce speed of operation, with high power input, in the machine itself. The accuracy which might be very expensive to produce in the machine could then be produced more easily with the aid of the control mechanism. The machine need not be superior in respect of those functions which could be more economically controlled by the control mechanism.

Mr. Beer felt that Sir Walter Puckey did not disagree with him quite as much as he contended. The question of whether he was old-fashioned was somewhat relativistic. Either he was old-fashioned, and people no longer thought in this way, or Sir Walter was ahead of everyone else in his thinking. He had not found the family tree in cybernetic clouds. He could produce books on management published this year showing that it still existed. Members were living with it every day, and he was quite sure that he had not been speaking of something which had already passed out of existence.

On the question of doing a disservice to industry, what he had said was that this kind of thing was all right, but that there was something about the new mechanisms that we were using in the local areas that would make the process wasteful. It could be more wasteful than in the past when, say, two things were done in different areas of the company simultaneously because of faulty liaison. It was a trivial

example, and the position was much better put in the Paper. His point was that the decisions, the information flow and so on, taking place in electronic machinery in the local areas, were inaccessible to the remainder of the organisation. Thus the wastefulness of the process would be amplified. He did not think they could do anything else but push forward locally. What one had to do at the same time was look more closely and urgently at the deeper levels.

Mr. J. Seeley (*Methods Engineer, Rotax Ltd.*) referring to Dr. Koenigsberger's point about liaison between control design and machine tool design, asked whether this was best achieved by setting up a control engineering function within the machine tool company, or whether the two functions could exist separately.

Dr. Koenigsberger said that it was a difficult question to answer specifically. He would not like to separate the two into watertight compartments. He was not a cybernetician, but it was one of those cases where boxes were extremely dangerous. The design of the machine ought to be correlated in a very flexible way, such that all the other functions could work together without rigid separation.

Mr. W. F. S. Woodford (*Institution Secretary*) said that he did not propose to agree or disagree with anything that Mr. Beer had said and thus possibly expose himself to ridicule, but he would like to take what he had said and examine it for a moment, *vis-à-vis* the comparison of the industrial organisation chart as a feudal system and the human organisation as a non-feudal system. He imagined that Mr. Beer was thinking of the kind of feudal system in which the man at the top had absolute authority. In the human organisation, on the other hand, there was no absolute authority; a number of autonomous organisms were inter-related and interacted with one another.

He might here be the victim of a " thought block ", but he was under the impression that the human being was controlled by will — a force independent of the organs, yet controlling them. Had Mr. Beer examined the problem of free will? If so, had he rejected it as being spurious and a thought block? If he accepted it, did he envisage an industrial organisation, consisting of autonomous but inter-related organs, being controlled by a will? Did he envisage a company generating a will power independent of itself? How was such an aim likely to be achieved?

Mr. Beer said that a great deal depended upon what was meant by " will " in this context, and here one could easily pass into the realm of theology. He thought it possible to speak of an assembly, whether it be a company or a brain, as behaving in a way which the observer declares as exhibiting "will". He was avoiding saying whether he thought that it was an entity or not for the simple reason that he did not know! Companies certainly looked as if they had will. A senior industrialist had told him that he had never had to vote on company affairs. This was surely because the whole machine was generating a corporate will. It was very difficult to find adequate words to express one's views about this new area of investigation.

He had spoken of wholes being greater than parts. One lacked the necessary scientific words. It had always been an area for philosophy. Suddenly it had become an area for science, and philosophers' words were inadequate. He thought it possible to deal with what was worrying the questioner without invoking the concepts that he sought to invoke. In 1958, Ross Ashby had delivered a Paper of incredible importance at the Teddington Symposium on the Mechanisation of Thought Processes. His subject had been habituation, which was analogous to the case now being considered. When people were habituated to something, and had reached the stage of ignoring it, they appeared to the observer to be exercising discretion. " Discretion " was another term like " will ". It had the same impressiveness, the same dignified association. One had to be very careful when talking about things which were really the properties of human beings and " soul ", if one liked, and those which were artefacts.

They would recall the case of Grey Walter's tortoises, which were comprised of two cells only. They exhibited behaviour which, to the observer, looked like a courting dance. Describing the construction of the tortoises, in which motive power was provided to the back wheels and the front wheel of the tricycle was steered by the response of a photo cell to light, Mr. Beer told how Dr. Walter had applied a modification, in the form of a light on the top of the shell which came on if the tortoise stopped but was still functioning. When set in motion the tortoises had touched momentarily, they had stopped, and the lights had come on. Each photo cell had responded to the light on the other's shell and they had advanced towards one another in a manner which resembled a courting dance.

This was an example of an artefact exhibiting characteristics that one had come to regard as volitional will and discretion. Until the stage was reached where one could no longer produce behaviour in a machine to which one of these " charming " words was attached, there was no need to try to answer the question in the sense in which it had been meant.

The **President** expressed the thanks of all present for the splendid addresses given by the speakers, not to mention the excellent way in which they had responded to the discussion. A real object lesson had been given in the fact that the whole was greater than the sum of the parts. He would not be breaching confidence if he revealed that he was somewhat relieved that Mr. Beer had been up to his usual form. Before the meeting he had asked Mr. Beer how he was and had learned that Mr. Beer had been suffering from chronic amnesia. On inquiring how long he had had the complaint, Mr. Beer had said, " What complaint?"

The Symposium then adjourned until the following day.

THE EDUCATION IN GREAT BRITAIN OF THE YOUNG PRODUCTION ENGINEER

by F. W. COOPER, B.Sc., M.I.Mech.E., M.I.Prod.E.

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This lecture was given to The Polish Society of Mechanical Engineers and Technicians, in Warsaw, on 28th June, 1960.

A translation was made by Andrew Z. Idzkiewicz, M.Eng.Sc., and was available to members of the Society.

A VISITOR to the United Kingdom embarking on a study of the route to professional engineering will be quickly confused by the complexities encountered. The majority of such engineers do not come up through the Universities, but through the Technical Colleges by full-time, sandwich or part-time courses — I shall be calling this "The Second Route". He will find in the Colleges a veritable army of potential craftsman, technicians and technologists studying not only many diverse courses, many of which may well seem inappropriate, but many also tinged by the local needs of industry.

But having cut his way through the maze he will see that the door to progress is never slammed in a student's face and that the roads to the top, some easier than others, are open, as indeed they are in Poland, to the boy from the humblest home. The very solid core of students will be found coming from homes where the father is a skilled worker.

My visitor will remark on the large number of engineering institutions, so different to the pattern seen in many Continental and Commonwealth countries. I believe our famous railway engineer, George Stephenson, was partly responsible for this

multiplicity, when in 1847, on being refused admission to the first Institution, the Institution of Civil Engineers, he thereupon founded the Institution of Mechanical Engineers. Many times since, engineers have been dissatisfied with the services provided by senior Institutions and have broken away — the founding of the Institution of Production Engineers in 1921 is an example.

He will also remark, I think, that only three years is normally spent in the Universities in obtaining a first degree in Engineering and he will see that there is no pretence that the young man with such a degree leaves as a complete engineer, or indeed, an engineer at all. There is a general preference for them to spend a few years in industry before returning for post-graduate studies.

Should my visitor have reached our shores in the last year or two he will be aware that we are in the middle of a rather agonising reappraisal of our educational methods, particularly that of Further Education carried out by Technical Colleges. Also strenuous efforts are being made to increase the output of scientists and engineers. You may perhaps profit by our errors if I devote a few minutes to the situation as it existed two or three years back.

the immediate past

the second route

Since I shall be talking a lot about the "second route", believing this to be the distinctive feature of our Further Education set-up, I have shown in Table I the pattern of qualifications of Graduate and Corporate members admitted to the senior Institutions in 1958, and how it is hoped the situation will develop next year. Table II gives an analysis, by branch of engineering, of engineers who qualified for the first time in 1958. I have no need to emphasise further the importance of the second route and will proceed to further detail.

the schools

Secondary Education in the United Kingdom is from 11+ to 15 years and then voluntary to 18 years, largely in the grammar schools. Fig. 1 may interest you in showing the three main types of schools, Modern, Technical and Grammar, coupled with a newer type, the Comprehensive (which covers these three streams) and also the Independent Schools. I would particularly draw your attention to that part immediately below the total population line of boys employed in industry:

Block "A" gives those released for full-time education in Technical Colleges; "B" those released part-time, usually one day per week and "C" and "D" those who are not released but continue their education in evening only classes. "The Gap", of which we are not proud, shows the boys who are receiving no further education. Fig. 2 shows that the Grammar Schools supply the vast majority of University entrants.

the universities and technical colleges

From school the two routes to my Institution were by:

(a) the Universities — usually a first degree in Mechanical Engineering containing, perhaps, some little work on Production Processes and in Management background subjects;

(b) the Technical Colleges — by obtaining the Higher National Certificate in Production Engineering by part-time day release. A useful feeder for this course has been by transfer of young men with the Final City and Guilds

Qualifications	1958 (*Actual*)	1961 (*Forecast*)
	Engineering	*Engineering*
University degree or diploma	3,067	3,800
Diploma in Technology	4	750
Associateship	369	420
Higher National Diploma	298	440
Higher National Certificate	3,953	5,220
Institution examination	814	820
Other Qualifications	1,181	1,000
Total	9,686	12,450

TABLE I

Pattern of qualifications of Graduate and Corporate Members admitted to senior Institutions

Branch of Engineering	*University Degrees and Diplomas*	*Membership of Professional Institutions (excluding graduates)*	*Total* Number	Percentage
Aeronautical	718	231	333	3.5
Chemical	180	51	231	2.4
Civil and Structural	309	729	1,038	11.1
Electrical	344	1,314	1,658	17.8
Gas	5	87	92	.9
Marine	3	724	727	7.7
Mechanical	378	2,370	2,748	29.6
Mining	77	316	504	5.5
Metallurgical	111			
Municipal	9	225	234	2.5
Naval Architects	13	140	153	1.6
Production	—	432	432	4.7
General Engineering	201	—		
Pass Degrees	786	—	1,187	12.7
Diplomas (estimate)	200	—		
Total	2,718	6,619	9,337	100

TABLE II

Analysis, by branch of engineering, of engineers qualified for first time in 1958.

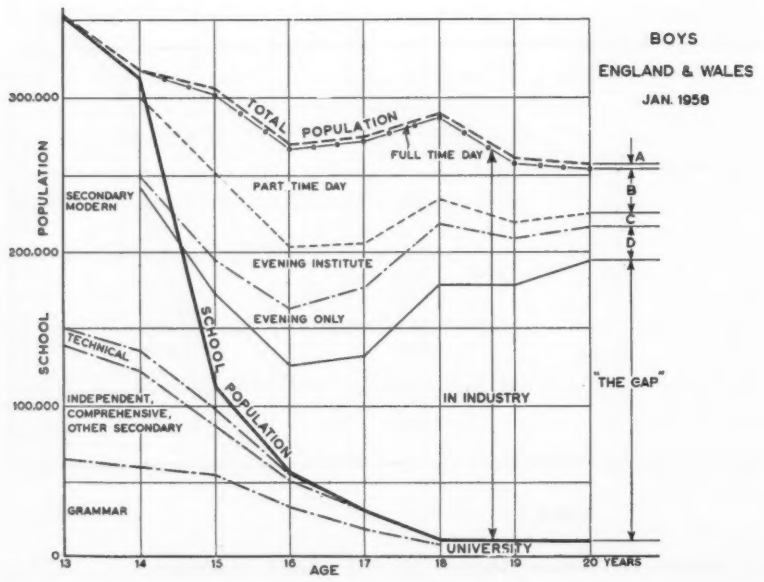
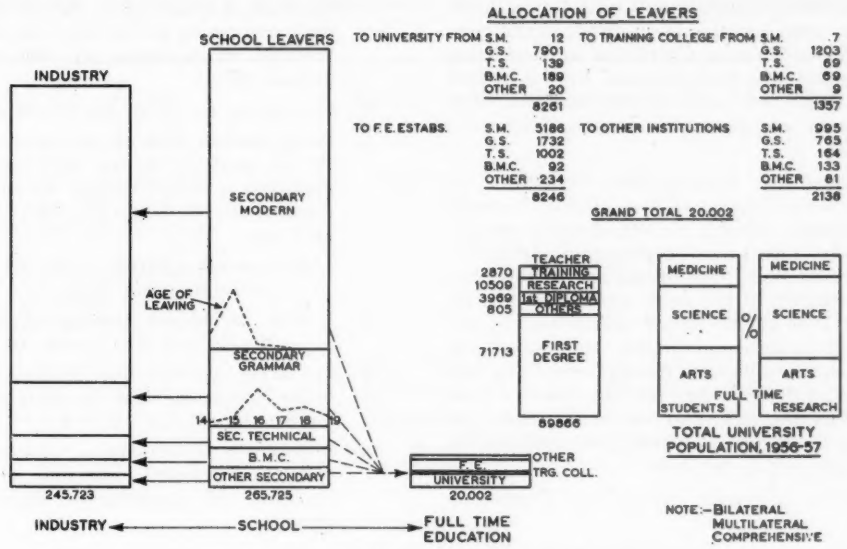
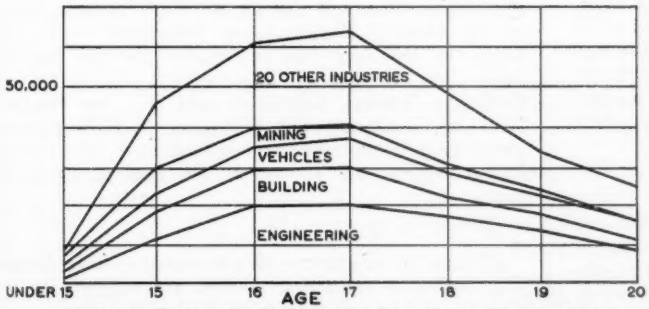


Fig. 1.

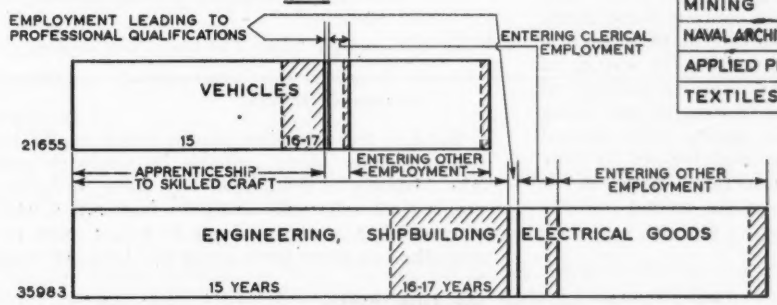


BOYS—SCHOOL LEAVERS YEAR ENDING 31.7.58

Fig. 2.



BOYS RELEASED BY EMPLOYERS FOR FURTHER EDUCATION 1958



ANALYSIS BY INDUSTRY AND OCCUPATIONAL CATEGORY FOR BOYS ENTERING INDUSTRY JAN. TO DEC. 1958

Fig. 3.

SUBJECT	O.N.C. ORDINARY NATIONAL CERTIFICATE	H.N.C. HIGHER NATIONAL CERTIFICATE	H.N.D. HIGHER DIPLOMA
BUILDING	1597	929	77
ELECTRICAL	4771	2165	110
MECHANICAL	8599	3926	246
PRODUCTION		542	5
CIVIL		278	
CHEMICAL ENG.	1459	61	
CHEMISTRY		882	
COMMERCE	380	7	
METALLURGY	373	269	
MINING	715	205	135
NAVAL ARCHITECTURE	100	47	
APPLIED PHYSICS	405	169	
TEXTILES	129	49	

TABLE (i) 1958

Machine Shop Engineering Certificate, a qualification rated for the lower grade technician. The Higher National Certificate in Production Engineering was badly delayed by the Second World War and only started in 1942. The number of awards in the session 1958 - 1959 was 650.

Fig. 3, Table (i), showing the distribution of Ordinary National Certificate and Higher National Certificate awards, indicates the considerable momentum gained by mechanical engineering. Indeed I think, and I trust I shall not offend any of you here, that many members of the older established Institutions find it difficult to adjust themselves to the importance of modern production techniques and the new " tools " available to management. The fact that the average designer has not one hour's tuition on such techniques, and that we as a nation are dependent on the export of highly processed articles, leaves them apparently unmoved.

Fig. 4 shows a typical course for Production Engineering.

National Certificate work has been, and will continue to be for many years, the backbone of the work in colleges and since their inception in the early 1920's both industry and the Institutions have welcomed the discipline of such courses and successful students gained considerable exemption against the Institution's examinations. Industry having four days of the week for practical training, extending from the age of 16 years to 21 years (an equivalent of four years against the equivalent of one year full time education in the college), was well pleased with the correlation of academic and practical training and particularly with the *immediate* usefulness of the younger men at the age of 21 years. The cost to industry was in effect but one day's pay per week whilst at college.

standards of the second route

I would not like you to think that the standard of the students in the second route is second-rate. A recent Ministry of Education report shows that nearly half of the top 10% of our most able boys leave school at 16 years or before — these fall into the catchment area of the colleges as does the next layer on the milk, which again contains some pretty good quality cream. Despite all this, many years in a Technical College have shown me that the wastage in National Certificate and craft courses is appalling and that we are not, by any means, training all our young people to the limit of their ability. The general realisation of this by all concerned has led to some serious thinking and some considerable change of the pattern of Further Education in the second route.

the re-appraisal

schools

Although work done in the schools is the foundation on which we build, I have little time here to dwell on the proposed recommendations for our schools but, briefly, they are :

(i) the legal leaving age raised to 16 years (we shall not, owing to the large size of classes and shortage of teachers, see this until at the earliest 1970);

(ii) compulsory part-time day release until 18 years;

(iii) whilst specialisation in grammar schools, from 16 - 18 years, if not too wide nor too deep, is approved it should occupy no more than two-thirds of the teaching time, the remainder being used for :

  (a) common ground where arts and science specialists meet and;

  (b) a period for making science specialists literate and arts " numerate ";

(iv) the larger size of comprehensive school allows better streaming and an economical size of higher classes;

(v) entrance to Universities is too complicated and competition fierce although for boys the Diploma in Technology may relieve the pressure.

the technical colleges

It is my own experience that the boy in National Certificate courses is driven hard up a narrow lane, a lane with high hedges and littered with those who have fallen by the wayside.

An analysis reveals that of every 100 boys who enter directly into the five-year course only 26% obtain the Ordinary National Certificate and 10% the Higher National Certificate. With qualifications in the General Certificate of Education (ordinary level) the first year can be omitted and the figures here show a distinct improvement of 51% for Ordinary National Certificate and 26% for Higher National Certificate. You will agree that the figures given are very worrying and in both cases only about half complete the course in the minima of 5 - 4 years.

The faults appear to be :

(i) lack of integration of school and college (short full-time induction courses are suggested);

(ii) faulty selection for jobs by industry and faulty selection for courses by College, industry—and the student;

(iii) not enough time (230 hours per session);

(iv) no breadth—too concentrated on immediate vocational training.

Some of these troubles can be cured by the longer teaching hours made available by sandwich courses. The Ministry of Education now have in hand proposals that will make entry to National Certificate courses selective and we hope that as a result of this and other measures the wastage will be much reduced.

the Institutions

The Institutions were not directly concerned in these matters but having raised the standards of their examinations (and they are the sole arbitrators of

HIGHER NATIONAL CERTIFICATE IN PRODUCTION ENGINEERING

	Typical Course Subjects	*Additional subjects required for I.Prod.E. A.M. Examinations*		
1st year	Practical Mathematics Engineering Science Engineering Drawing	English	Pt I	English
2nd year	Practical Mathematics Engineering Science Engineering Drawing		Pt I	Engineering Drawing
3rd year	Practical Mathematics Applied Mechanics Production Processes	Heat, Light and Sound Principles of Electricity	Pt I Pt I Pt I Pt I	Applied Mechanics Heat, Light and Sound Principles of Electricity Production Processes
	—— TAKE O.N.C. ——			
4th year	Practical Mathematics Adv. Production Processes Materials and Machines		Pt I	Mathematics
5th year	Theory of Machine Tools Metrology Metallurgy	Tool Design	Pt II Pt II Pt II Pt II	Gp. B Theory of Machine Tools Gp. B Metrology Gp. B Tool Design Gp. A Metallurgy
	—— TAKE H.N.C. ——			
POST H.N.C.		Industrial Management Management of Production Management of Men	Pt III Pt III Pt III	Industrial Management Management of Production Management of Men
	—— TAKE ENDORSEMENTS ——			

NOTES :-

1. The above course is designed for the apprentice obtaining one day per week release from Industry to attend the local Technical College.

2. At least one evening per week would also be required in the first five years.

3. The additional subjects for Parts II and III would require (after the age of 21 years) 2 or 3 evenings per week for 2 years, making a total of 7 years part-time study to meet the Institution's A.M. Examination.

Fig. 4.

these) in recent years — and since so many members come in by exemptions — they were bound to ask if a Higher National Certificate qualification, little altered over 30 years, continued to meet their requirements. It will interest you to know that the awarding body for National Certificates in say, Mechanical Engineering, is jointly the Ministry of Education and the Institution of Mechanical Engineers. This Joint Committee issues Notes for Guidance on suitable courses and approves or rejects courses and in doing so examines subjects, syllabuses, teaching hours, laboratory facilities and teachers' qualifications. The very considerable clerical work is handled by the Institution concerned and the certificates are jointly signed by the President of the Institution and the Principal of the College.

Now I must emphasise that despite the active participation of the Institutions National courses are not supposed to meet their examination requirements — in fact, the originators of the National Certificate aimed at a qualification suitable for a technician. However, the substantial exemptions given until recently meant that the majority of their entrants came in by this route. Inevitably the technician flavour was lost and courses were more and more designed to meet Institution requirements. Maybe this was very wrong, but there can be no regrets that it laid solid foundations for the second route. Those few candidates who take the Engineering Institutions' own examinations are usually the ones who "missed the boat", or those from overseas who cannot obtain suitable exempting qualifications. But the Institutions' examinations do set standards observable to all and exemptions naturally become of paramount importance. In the Institution of Production Engineers all applications are examined individually by the Education Committee and the results published in a leaflet "1960 Associate Membership Exemptions". The Institution, therefore, in adding English and physics subjects at the lower level and extra technical and, sometimes, management subjects at the final stages posed a serious problem to all concerned — student, lecturer and training officer.

additional requirements

I show in Fig. 4 *additions* over and above the plain Ordinary National Certificate and Higher National Certificate necessary to meet the Institution of Production Engineers' requirements. For some years students have been taking these extra subjects as post-Higher National Certificate, a very undesirable practice, and it can be no surprise that very recently the senior Institutions announced that they will have no more of this and that Part I subjects must be cleared before the final year of the Higher National Certificate. Also exemptions will be on a subject-for-subject basis. The additions I have shown in Fig. 4 would do this but you see the snag — seven years' hard labour for the part-time day release apprentice, and eight years for evening only — and never a foot put wrong!

And so the Institutions have declared their belief that for the technologist, their future member, part-time day release leaves much to be desired and they call on industry to support sandwich release leading preferably to the Diploma in Technology. They now regard the plain Higher National Certificate a suitable qualification for a higher grade of technician — in other words, back 40 years to the original conception.

sandwich release

definition

By this is meant full-time spells in College interposed with periods in industry for practical training. The common pattern is six months' College, six months' industry per year. We have had a small number of sandwich courses for many years, but the advent of the new award of the Diploma in Technology has been a great stimulant.

the diploma in technology

In early 1956 the Government announced a five-year plan for improving and extending facilities for technical education. For Technical Colleges the target was to increase to some 15,000 the annual output of students from advanced courses and at a lower level double the present number of 350,000 students released by their employers. £80,000,000 was allocated for buildings and £17,000,000 for equipment. For the Universities the target was an annual output of 20,000 scientists and engineers, but it was clear that the major part in increasing the number of professional engineers would be played by the Technical Colleges, and in particular by the new Colleges of Advanced Technology offering the Diploma in Technology courses.

The National Council. Both the latter events were mooted in 1945 but I am afraid we, as a country, move slowly. Nineteen-fifty-six, however, saw the establishment of the National Council for Technological Awards with an independent high-powered governing body and two strong Boards of Study, one being for engineering. The Chairman of the Engineering Board of Study is one of our leading members, and there are also 10 members from the educational field, 12 from the professional institutions and five from the Ministry of Education.

Major Colleges were asked to submit schemes and teams from the Board of Study then subjected colleges to rigorous inspection. So high were the standards set that the Universities accepted the award as of honours degree standard even before the first awards were made — a most unusual occurrence. In particular the Council examined staff qualifications, research facilities, laboratories, libraries and hostel accommodation — 75% of the courses submitted were on first application rejected due, primarily, to lack of these facilities.

Courses. There are now courses for 10 engineering or allied subjects and seven for science with a total of approximately 4,000 students. Fifteen courses are full-time, of three years' duration, and 72 sandwich of four years' duration.

Fig. 5 gives details of two production courses; Birmingham College of Advanced Technology, which last year had the first output in the country of eight awards in Production Engineering, and a most interesting course at the Brunel College of Technology. Although not for a Diploma in Technology the Automation course at Twickenham has interesting features.

Entrance Conditions. Grammar School (or equivalent) boys with mathematics and physics at advanced level and three subjects at ordinary level form a majority of the entrants but adhering to the national policy of the "open door" part-time students obtaining a very good Ordinary National Certificate can transfer to Diploma in Technology courses. Of the number of new entrants at the beginning of this year 1,032 qualified by General Certificate of Education and 463 (mostly engineering students) by Ordinary National Certificate.

Award. The examinations involve internal and external examiners, the latter appointed by the National Council. The project undertaken in the final year is an essential part of the award and the Principal of the College must also certify that the correlated practical training has been successfully completed. There are three divisions — first and second-class honours and pass, and the letters Dip.Tech.(Eng.) are carried.

Views of the Institutions. I am pleased to say that the Institution of Production Engineers was one of the few Institutions, from the very inception, to give the Diploma in Technology scheme its unqualified support. The increase in teaching hours permits much needed improvement in teaching methods (the National Certificate was perforce largely blackboard and chalk), the introduction of general studies, extra-curricula activities and exercises and projects. The provision of adequate libraries and reading rooms, some remarkably good hostel accommodation and above all the upgrading of staff provide some of the advantages of University life. Finally, and probably most important, is the close co-operation that is now necessary between College staff and the firms providing the students. This ensures a sound and varied training correlated with the work done in the college and covering a total period of approximately two-and-a-half years. We give complete exemption from our examinations against the Diploma in Technology in Production Engineering.

Views of Industry. It is early yet but I have little doubt that the Diploma will rank equal in the eyes of industry with that of the Engineering Degree — in fact, if past experience is anything to go by, better. The students are nearly all works-based, that is, they are employed by firms who pay them wages whilst in College, as well as for the periods in the works. I have no objection to College-based students if, and it is a big if, they can obtain adequate practical training.

A Higher Award. The Council have recently announced that a higher award, roughly equivalent to the University Ph.D., will be made and will carry the letters M.C.T. (Member of the College of Technology). The award will normally be made for a programme of work satisfactorily carried out, generally, in industry and at college. The programme may be concerned with any technological aspect of industrial activity, for example, research, development, design, production or market investigation and is to be of such a nature that it is likely to result in a useful contribution to technological knowledge. It requires industrial experience and academic study extending over a substantial period, and three years is the approximate period that the College of Technology has in mind.

The Higher National Diploma. We have had for some time a diploma taken in sandwich courses, and somewhat equivalent to the Higher National Certificate "plus". It was, however, not very popular with industry but the success of the Diploma in Technology has done much to revive it — in fact, the recent increase in other "sandwich" release is most interesting.

	1956	*1959*
Higher National Diploma ...	1125	3254
London University External Degree	4	307
College Associateship	140	973

The catchment area for Higher National Diploma was normally those boys with a good Ordinary National Certificate but it is now widened to take the boy of 18 years from the grammar school (or equivalent) who has Mathematics, General Certificate of Education (A) and has studied a science subject in his last year at school. Since on an average only about half of the last year boys aim at University education, some excellent material is available. The course is usually three years' sandwich and we would expect it to meet the Graduate requirements (Parts I and II) of our examination. Practical training is extended to a total of two-and-a-half years and entrants are usually, except in difficult employment areas, works based. We welcome such courses if only for the increase of teaching hours, which are approximately 2,000 against 460 for Higher National Certificate. For awards see Fig. 3, Table (i).

teaching methods in the colleges

You will perhaps allow me to interpose a little on teaching methods before dealing with the Universities. We realise that all is not well in the Colleges and that since the last War it has been most difficult, particularly in Production Engineering, to obtain suitable staff, with not only the wide academic qualifications, but with some sound industrial experience. We have few Training Colleges offering full-time courses for technical teachers but the number of places available is being increased. The Ministry of Education regularly have short residential courses in the long vacations dealing primarily with teaching methods. My Institution has an annual Summer School, this year to be held at the College of Aeronautics, Cranfield, the subject being "Machine Tool Control

TYPICAL DIPLOMA IN TECHNOLOGY COURSES

A. Birmingham College of Advanced Technology — *Dip.Tech. in Production Engineering 4-year Sandwich Course*

year	*Subject*	*Hours per week*	*Associated Practical Training in Industry*
			Basic Training
1st	Mathematics	varies according to qualifications held on entry.	Bench Work
	Physics		Machine Shop
	Chemistry		Measurement and Inspection
	Principles of Electricity		Metal-Forming Processes
	Applied Mechanics		Metal-Joining Processes
	Applied Heat and Mechanics of Fluids ...		Patternshop, Foundry Techniques and Casting Processes.
	Engineering Drawing		Heat Treatment Processes
	Economic and Human Relations ...		Assembly and Erection
2nd	Mathematics	$4\frac{1}{2}$	Basic Processes
	Principles of Electricity	3	
	Strength of Materials and Mechanics of Machines ...	3	
	Mechanics of Fluids and Applied Thermodynamics ...	$3\frac{1}{2}$	
	Metallurgy	$3\frac{1}{2}$	
	Engineering Drawing or Applied Physics	$2\frac{1}{2}$	
	Technology of Production	4	
	Economics and Human Relations	3	
3rd	Mathematics	3	Inspection and Test
	Strength of Materials and Mechanics of Machines ...	5	Machine Tools
	Mechanics of Fluids	$2\frac{1}{2}$	Tool Room
	Metallurgy	2	Tool Drawing Office
	Electrical Engineering and Electronics	3	Work Study Department.
	Design and Application of Production Equipment ...	3	
	Statistics	$2\frac{1}{2}$	
	Measurement and Control of Quality	$2\frac{1}{2}$	
	Work Study	2	
	Economic and Human Relations	3	
4th	Management Principles and Practice	3	Advanced Metrology and
	Factory Organisation and Production Control	2	Standards Engineering
	Factory Costing and Estimating	1	Tool Engineering
	Industrial Psychology	1	Experimental and Development
	Mechanics of Machines and Vibrations	3	work in Processes Planning Section
	Mechanics of Metal Processing	3	Factory Organisation and Production
	Measurement and Quality Control	3	Control
	Plant Layout and Material Handling	3	Factory Costing and Estimating
	Design and Application of Production Equipment ...	3	
	Project Work	8	

Entry Qualifications. Students must (i) have obtained an Ordinary National Diploma with high marks, or (ii) have passed G.C.E. examinations at Advanced Level in Mathematics, and Physics, and at Ordinary Level in Chemistry, English and in one other subject (or equivalent qualifications), or (iii) have obtained an Ordinary National Certificate with high marks.

Fig. 5A.

B. Brunel College of Technology —
Dip.Tech. Course in Production Technology 4-year Sandwich Course

1st year	*Hours per week*
Physics	4
Chemistry	2
Physiological Psychology	3
Mathematics and Statistics	4
English	1
Production Materials and Processes	3
Engineering Drawing	2
Industrial Practical	1
Tutorials	2
Private Study	8

2nd year	
Physics and Electronics	5
Chemistry	1
Applied Psychology	1
Mathematics and Statistics	2
English	1
Production Materials	3
Production Processes	6
Industrial Practical	1
Tutorials	2
Private Study	8

3rd year	*Hours per week*
Applied Electricity	4
Applied Psychology	2
Mathematics and Statistics	2
English	1
Production Processes	5
Measurement for Production	4
Production Improvement	1
Industrial Practical	2
Tutorials	1
Private Study	8

4th year	
Automatic Control and Applied Electronics	2
Applied Psychology	1
Applied Statistics	3
English	1
Specialised Production Processes	3
Current Development in Production Materials	2
Current Development in Social Sciences	1
Production Organisation	3
Final Project Preparation	6
Tutorials	2
Private Study	6

Fig. 5B.

C. Twickenham Technical College —
Engineering Diploma Course (Automation) 4-year Sandwich Course

1st year	*Hours per week*
Mathematics	4*
Principles of Electricity	5*
Workshop Technology	—*
Physics	5*
Heat Engines	3*
Engineering Chemistry	3*
Applied Mechanics	3*
Engineering Drawing	—*
Manufacturing Materials and Processes	2*
English	2*
Private Study	3*

* For O.N.C. entry.

2nd year	
Mathematics	3
Metrology and Machine Tools	3
Metallurgy	2
Jigs, Tools, Fixtures	3
Strength of Materials	3
Theory of Machines	3
Electrical Technology	3
Engineering Physics	3
Mechanics of Fluids	2
Manufacturing Materials and Processes	2
Private Study	3

3rd year	*Hours per week*
Mathematics	3
Metrology and Machine Tools	3
Metallurgy	3
Jig and Tool Design	3
Strength of Materials	3
Theory of Machines	3
Hydraulic Systems	2
Theory and Performance of Electrical Plant	3
Applied Electronics	3
Industrial Organisation	2
Writing and Presentation of Technical Reports	2

4th year	
Advanced Metrology and Machine Tools	6
Advanced Mechanical Engineering	6
Utilisation of Electrical Plant	4
Automatic Control Systems	4
Industrial Organisation	4
Project	6

Fig. 5C.

Systems". The newly established and extensive material cutting laboratories will be used for demonstrations.

The main fault has probably lain with heavy teaching programmes and the large amount of work to be done in National Certificate Courses in such a short time. Only now are Colleges experiencing some relief in accommodation for students, but still many of them, even now, literally overflow with students.

Now at last with sandwich courses and improved facilities we have a chance of doing something better. All this is very new but I will give you some details culled from the Brunel College of Technology, details of a course of which you have already seen in Fig. 5B.

The course in Production Technology, and for the award of the Diploma in Technology (Eng.), is intended as a stage in the development of the grammar or equivalent school leaver who might be expected to manage a specialised or a production unit in an industrial firm by the time he is in his thirties. By current standards he might be expected to aim for a position in which he could earn between £1,100 - £1,350 a year by the time he is 30.

The course assumes a growing sense of responsibility in the student and aims to develop this. Its most important feature is the opportunity to match theoretical knowledge of physical and social processes with practical industrial experience. During the four years' experience in Colleges and firms some of the teaching is conducted with the help of Companies collaborating with the College, irrespective of the firm from which the student may come.

The candidate's suitability for admission to the Course is judged on his educational background, on the recommendations of his school or firm, and upon interview. Candidates are required to offer a short statement of their reasons for wishing to join the Courses.

Candidates must seem likely to become capable of carrying responsibility for the work of other people as well as for technical innovation. It is hoped that the procedure of selection will minimise from the start the possibility of the student finding that his potentialities fall short of his own aspirations, and of the demands made upon him later.

The first year, as well as affording knowledge of science and engineering, will establish an analytical method of which the student will bring to bear upon his elementary industrial Field Studies. Students jointly prepare tasks, and having established a method of work each student is required to find and order the facts and present his own version of a solution. By the second year, it is planned with the co-operation of local firms to arrange a Field Study which requires a fact-finding visit to a firm abroad; it is hoped a bursary will be available to cover the essential cost of the trip. Each student will also undertake a series of industrial Tasks which, though limited, are nevertheless of some slight economic consequence to a firm and thus oblige a student to be on his mettle. Jobs will be sought for the student which will be just within his growing competence. In the third or fourth years it is hoped that one such temporary job will include an opportunity for the student to work closely upon tasks for which a senior general manager is accountable. Also in the fourth year, the student will write up one of his own field studies in the form of a project report as a part of his final examination.

Support, guidance and a review of his progress in academic and industrial work are available to the student in tutorials. Academic Tutorials, with a maximum of three students, are held weekly by Departmental Tutors during the College phases and can be made available during Works phases. Industrial Tutorials are held weekly during the College phases of the first and second years. Industrial Tutors are men who are in industrial positions comparable to these towards which the student aspires and who are able to appreciate the student's difficulties. From the beginning of the Course Free Time is included in the College phase of the programme to allow the student to devise activities for himself: his success depends upon his total activities not only upon academic prowess.

Students sponsored by their employing firms (works based) will have the major part of their industrial experience in their own company, whereas students not yet emloyed by a firm (College based) will have the major part in local manufacturing firms selected by the College. Much of the Course has been devised with the close co-operation of the Departmental Panel. A number of firms manufacturing different types of metal and electrical equipment, producing chemicals and processing food, severally offer to all students opportunities for industrial Field Studies and Tasks related to their academic work. As far as possible these will be arranged during the four years to give the student insight into:

(i) the technical operations of a range of production departments, but especially those of his own firm or intended industry;

(ii) the technical operations of specialised technical departments immediately ancillary to production (e.g., toolroom; drawing office; development and design; research; inspection.);

(iii) the procedures of specialised departments (e.g., buying, sales, personnel.);

(iv) the demands made upon a person at different levels of seniority in production hierarchy. Levels considered:

  (a) General Works Manager or Managing Director or Deputy Managing Director;

  (b) Superintendent or Departmental Manager;

  (c) Supervisor;

  (d) Operator.

(v) the organisation of a firm.

From the start of the Course production methods and materials are studied against a background of mathematics and science.

Physics and chemistry are considered a necessary background for appreciating the properties of metals and plastics and methods of processing or manufacturing them. Physiological psychology and the study of social processes are considered the necessary background for appreciating the human implications of equipment design and use, and of the many procedures used in manufacturing, such as inspection, work measurement, and payment system. In his last year each student specialises in the particular technology of his firm's industry.

A student's eligibility for the award of the Diploma in Technology will be judged by his performance throughout the whole course.

At the close of each College phase, the student writes his examinations and is given practical tests. The examination papers require the student to use and relate his several different sources of knowledge and experience. In each year there is also an assessment, with the co-operation of his firm, if he is employed, of the student's progress in his industrial work. A representative of the firm will be invited during the course to examine the student orally on a piece of his practical work. In his final year he prepares a field study (his Finals Project) of one special aspect of technology, completes and writes this during his last Works phase, and submits it as a qualifying part of his Final Examination. External examiners will work with the College in assessing the results of the second and final years.

All this you will agree is a distinct step forward from the blackboard and chalk method and I anticipate that such methods will be generally used in Diploma in Technology courses. Certainly in the case of Brunel I am looking forward to a very excellent end product — the manager of the future.

A very necessary provision if teaching is to be effective are adequate facilities for demonstration, experimentation and research, and here again I would like to consider a specific case, namely Birmingham College of Advanced Technology, situated at the heart of our great Midland industries.

Backed by 30 years' experience in Production Engineering studies a separate department was established in 1957. A consideration of such subjects as Metallurgy, Control Engineering, Statistics, Operational Research and Management subjects mean however that contributions are required by way of specialist lecturers and the following departments co-operate in this: Mechanical, Electrical, Building and Civil Engineering, Mathematics, Physics, Metallurgy, Chemistry, Industrial Administration, Biology.

The generous provision of laboratories allows for the expansion of technological work into fields other than the usual ones of Machine Tool cutting processes and Metrology. The following laboratories will be available in 1961 for teaching and research: Machine Tool; Advanced Processes; Heat Treatment (service): Jig Boring Room; Metrology and Standards Room; Research and Development; Precision Casting; Metal Flow Processes; Process Mechanisation and Control; Quality Control; Welding and Fabrication.

These will serve four main courses:

(i) sandwich course (four years) leading to the Diploma in Technology (Eng.);

(ii) part-time course (four years) leading to the Associateship of the College;

(iii) full-time Post-graduate course (one year) leading to the Diploma in Production Engineering and;

(iv) advanced, Post-graduate courses of a short period character for Senior Engineers.

All the courses are firmly based on technology since it is recognised that all studies stem from the product consideration in the first place, though the importance of effective man and machine management is not forgotten in the overall provision.

You will see from Fig. 5 that course "A" is not of narrow specialisation and in the first three years is broadly based to include Mechanical, Electrical and Production Engineering with some Planning and Control. The final year sees specialisation in Production Engineering and the requirement of a project involving a high standard of investigation and experimentation. Thus the successful student is able to move, in the most formative years, horizontally through an organisation, and, if later it is necessary in his future career, he can return for study in a particular specialisation.

Typical courses mentioned under (iv) above are: Case Studies for Quality Control and Materials Handling; Precision Measurement.

Another course which may interest you is one formed in the belief that the pattern of manufacturing activities today makes it essential that the training of an engineer, irrespective of his technological specialisation, should include a knowledge at least of the fundamentals of Production Engineering, if not an intensive application in detail. A 12-week full-time course for students, who had already obtained their primary qualifications — in most cases a University Degree in Engineering — was recently started. The courses have been planned to give a substantial time in the laboratories so that the problems of manufacture and measurement can be evaluated. Additionally each student is required to make an intensive study of at least one complex machine tool and to prepare a technical Paper on a subject which necessarily involves a study of current literature on the subject. Roughly 300 hours are available, the subjects being Machine Tool Technology; Metrology and Quality Control; Tool Engineering; Press Tool Technology; Production Metallurgy; Methods; Plant Layout and Materials Handling.

Research work in the College awaits the appointment of a Reader and other staff — these are proving almost impossible to obtain.

Such work as I have described shows a philosophy of approach which it is hoped will result in a continuing output of production engineers who, at the undergraduate stage, are not too highly specialised to prevent both horizontal and vertical movement within their organisations and at the post-graduate stage,

are capable of making a significant contribution to their profession.

(*At this point there was given a display of slides showing various laboratories and equipment of the Birmingham College of Technology.*)

the Universities

Let me emphasise that we have no equivalent to the Continental Technical "High School" or Technical University, and hence no ready-made establishments for the teaching of production engineering such as exists in Belgium, Denmark, Holland, Norway, Austria, Sweden, Finland, Switzerland, Germany and France or as in your Polytechnics.

The older forms of engineering in the United Kingdom found it a slow and difficult business to obtain "respectability" in the Universities and Production Engineering is finding it even more difficult. One would not quarrel in defining the purpose of a University as "the development of the student's ability to think logically, critically and constructively in relation to his chosen field of study; to acquire social interests and an appreciation of the broader field of facts and theories which may help him in later life" — but it seems to me an unfortunate exercise if this is used to confine Production Engineering to post-graduate courses.

Another will say that Production Engineering has a much smaller area of its own and a far larger area where it overlaps other disciplines; that it moreover spills into the fields in which normal branches of engineering are not normally in contact, for example, human relations involving psychology and the new fields developed from applied statistics. Such considerations, whilst perfectly valid, have retarded progress so much that I consider our national interests to be in jeopardy.

However, I must now give you details of what little we have, hastening to say that most of the little is of high quality.

undergraduate or first degree courses

Few of our University engineering courses have no subjects allied to Production Engineering but many such subjects are rather flimsy in character and are often optional; we can, however, find such as Metrology, Manufacturing Processes, Industrial Administration and Economics, Automatic Control, etc.

Fig. 6 shows courses at Manchester and Durham that have enough Engineering Production in the final year to justify thinking of them as first degree courses in the subject.

A few other Universities have a reasonably strong optional subject and at Imperial College, London, we find Workshop Technology is a compulsory subject in the first year and in the last year an optional is offered in Production Engineering. This comprises 10 lectures each in Production Processes ,Metrology and Industrial Engineering and 10 hours tutorial. Additional time is also available for the showing of industrial films. In the present session, out of 65 students studying Mechanical Engineering 50 are taking the production option and this, I think reflects the fact that the students clearly see the need for some work in this direction. If this tendency continues, those entering the sphere of design will at least be able to apply some knowledge of production at what is surely the correct and primary place, namely, the drawing board.

post-graduate courses

Greater strength is found here but before dealing with two Universities, situated very near to the Technical Colleges already reviewed, I would like to mention, as being of particular interest to this conference, the course just started at Manchester University in Machine Tool Design.

Manchester

In this course the basic principles and the latest developments concerning the design of up-to-date machine tools will be taught by both academic lecturers and experts from the machine tool industry. The Machine Tool Trades Association have established 10 scholarships for staff engaged in their industry. Largely because of the amazingly small number of graduates employed in technical positions in the machine tool industry it is impracticable, at present, to make this course formally post-graduate but it is hoped that this standard will be reached in the future. The minimum qualifications for admission are Higher National Certificate in Mechanical, Electrical or Production Engineering.

Students receive lectures dealing with performance requirements; design specifications and basic design and calculation data for machine tools; the principles of electrical engineering especially electronics; hydraulics; vibrations; friction and lubrication; control engineering; properties and behaviour of engineering materials; standardisation; metrology; ergonomics; safety regulations; economics of automation; etc. Design problems concerning machine tool structures, drive elements, slides, slideways and bearings are discussed, and laboratory exercises, work on actual design projects and visits to the works of leading machine tool firms in the country complete the syllabus of the course.

London — Imperial College

The course in Engineering Production is of one year's duration and leads to the Diploma of Imperial College (D.I.C.). The majority of entrants have an engineering degree, one or two have degrees in mathematics or physics and a few a Higher National Certificate (Eng.). Many have been turned away, but buildings now in progress should relieve the position. A period of about four years in industry after obtaining the primary qualification is preferred.

The subjects must carry a minimum of 50 lecture hours and I show in Fig. 6 the compulsory and optional subjects.

Three important aspects of this course are :-

(i) *A Special Task* : A dissertation is required from each student and is based on industry, theoretical or experimental work. The subject is usually chosen near Christmas, some reading done in

A. FIRST DEGREE COURSES

Manchester — College of Science and Technology

1st and 2nd years are common with Mechanical Engineering

3rd year

Mathematics and Mathematical Statistics
Strength of Materials
Designing for Production
Power Station Practice
Metrology
Commercial Law, Management Principles
Production Control, Labour Efficiency.
Theory of Machines
Hydraulic Control
Specification and Design of Equipment
Electrical Measurement and Control
Theory of Metal Processing

Durham — Kings College, Newcastle

1st and 2nd years are common with Mechanical Engineering

3rd year

Theory and Design of Machines
Engineering Administration
Engineering Production Processes
Industrial Health

and two of the following subjects :-
Engineering Economics
Fluid Mechanics
History of Engineering
Statistics
Strength of Materials

B. POST-GRADUATE COURSES

London — Imperial College

1st year course in Production Engineering

Compulsory subjects :
Industrial Engineering
Management and Industrial Administration
Statistics and Statistical Methods

together with a selection from the following list of optional subjects :
Production Processes I
Production Processes II
Dimensional Metrology
Gauging, Inspection and Testing
Industrial Sociology
Principles and Practice of Machining
Economics of Production Processes
Non-metallic Materials
Automation and Numerical Control of Production Processes
Operations Research
Plasticity of Production Processes

Birmingham

1-year course in Production Engineering

Production Management
Productivity Measurement
Work Study
Applied Statistics
Production Technology
Product Design and Process Planning
Plant Layout and Materials Handling
Production Planning and Control

Birmingham

1-year M.Sc. course in Operational Research

Operational Research Techniques
Mathematical Statistics
Principles of Engineering Production
Work Study
Analogue and Digital Computers
Productivity Measurement.

Fig. 6.

the Spring Term and after Easter four days per week devoted to the project.

(ii) *Seminars* occupy two hours per week for the whole session and fall into two parts :

(a) each student must give one lecture and reply to the subsequent discussion (a valuable exercise) and;

(b) lectures are given by outside speakers who are experts in their own field.

(iii) *Practical Work* occupies one complete day per week and is largely based on the individual interests of the students.

a higher award

For the award of M.Sc. a further 12 months is necessary and may well be a development of the task previously selected. In isolated cases two years, without the necessity of doing the Diploma of Imperial College course, is permitted. For example, one student is now engaged in evaluating management structures in industry with a view to defining relationships between individuals. Investigation is proceeding as to whether an organisation can be described from the point of view of analysis of the task to be performed by relating individual responsibilities to a limited number of parameters.

Birmingham

At the moment Birmingham is unique in having the only "occupied" Chair in Production Engineering, meaning that not only is there a department of Engineering Production but, owing to the generosity several years back of the well-known firm of Joseph Lucas Ltd., there is a residential Institute of Engineering Production forming part of the Department, and under the direction of Professor N. A. Dudley, M.I.Prod.E. There is available a £10,000 scholarship fund, and the course has been recognised for the D.S.I.R. advanced course studentships. The U.N.E.S.C.O. Fellowship fund has also enabled students to take this course.

The principal activities of the Department lie in the post-graduate field and are :-

(i) *one year course leading to the award of M.Sc. in Engineering Production* or a Diploma for graduates. Fig. 6 gives details of the subjects and I would mention that the course is now in its 11th year.

Students are required to attend lectures and tutorials and to undertake laboratory and industrial case study work. In addition, approximately one-third of the session is devoted to an individual project or investigation leading to a report or minor thesis and co-operation of industrial firms is sought in the provision of facilities for these projects. Recent titles include The Economics of Automatic Transfer Mechanism; Value Analysis; Data Processing for Planning and Control; A Review of Equipment Policy; the Organisation of Product Engineering; Incentives of Maintenance Workers; Mechanisation Planning; The Economics of Electrical Testing; Foundry Productivity; Factory Planning and Layout; Procedural and Organisational Analysis.

Extensive use is made of speakers from other faculties of the University, and visiting lecturers from other Universities, from industry and research bodies.

(ii) *A one year course leading to an M.Sc. in Operational Research* and now in its second year. Fig. 6 gives details of the subjects covered. Here the entrants must have honours degrees in Science or Mathematics.

Both these courses are over-subscribed and expansion awaits further building.

The Institution gives complete exemption to those successful in these courses.

(iii) A continuous series of short residential "*Productivity Study Courses*" are held at the Institute for senior production engineers and industrial executives. Duration is normally two weeks and all courses have an essential practical basis, so that each member is able to relate to the special productivity improvements problems of his particular industry. Each member is invited in advance to select and bring practical problems for consideration and discussion.

Such short courses have, I believe, a vital place in the training of a potential manager in at least providing him with a deep appreciation of some of the modern management "tools". On an average there are 24 courses per year attended by a total of about 500 engineers and executives.

Programmes include Work Study; Production Planning and Control; Operational Research; Linear Programming and Queueing Theory and Practice; Statistical Quality Control; Organisation and Methods; Design of Industrial Experiments; Predetermined Motion Time Systems; Business Games; Forecasting and Scheduling Production.

research

The amount of research performed will, I think, for some time be the distinctive feature between Universities and Technical Colleges but, if adequately used, the superior laboratories and equipment in the Colleges of Advanced Technology should (given the right staff — and this is a prime difficulty in the field of Production Engineering) rapidly diminish the gap.

Imperial College

Two main fields are covered :-

(i) Technology of Production Processes and,

(ii) Industrial Engineering and Management.

The former covers machine tools and tool or dies and investigations are proceeding into the forces which act on a milling machine frame, the behaviour of very hard yet brittle sintered materials, new tool and die materials based on the borides.

In Industrial Engineering we find problems in inventory and production control, notably arising in the field of batch production, in stock control systems

and replenishment policies, production scheduling, work study, interference and queueing, variety reduction.

Research at Birmingham University (Department of Engineering Production)

is directed to the discovery and understanding of the nature, characteristics and interaction of the agents of production and of the scientific principles upon which the planning co-ordination and control of industrial production are, or should be, based. Investigations undertaken are in the field of :-

> Machine Tools — determination of the characteristics and machine tool processes — their capacity in terms of rate of metal removal, surface finish and consistency of performance, their cost in terms of power consumption, tool life, setting time and maintenance.

Current work is on broaching, milling and precision grinding and special dynamometers have been developed to assist in this work. *Also* on the effect of skills and judgment in the use of equipment for measuring surface finish, the human factor in machine control; the characteristics of workers engaged in repetitive manual operations — paced and unpaced.

Also in the field of operational research, including the making of machine interference models, linear programming analogues and production control simulators.

The most complex, most challenging and potentially the most rewarding research now being undertaken in the Department is that which seeks to understand the entire manufacturing unit as a single process.

At Birmingham University (Department of Mechanical Engineering)

The Department of Scientific and Industrial Research has just made a grant of £31,200 for research on the dynamics of metal cutting and the dynamic design of machine tools under the direction of Professor A. S. Tobias.

At Manchester University

Research work carried out, or at present in progress, includes : influence of production processes on design consideration, design stresses, stress distribution and fatigue of fillet connections, load—carrying capacity of welded structural elements, influence of finishes obtained by machines and flame cutting on fatigue strength.

Also cutting conditions with carbide tools including formation of built-up edge, performance of specially designed dynamometers, spark erosion.

Also design of elements for machine tools suitable for automatic electronic control.

Also forming and other processes.

practical training

I need hardly say that my Institution, as far as membership is concerned, will have nothing to do with an applicant whose academic knowledge, received at University or Technical College, is not linked with adequate practical training. Much work is now being done by industry in this field and the advantages of appointing a Training or Education Officer and the establishment of a Works Training School is being generally realised by the larger firms. Smaller firms are beginning to participate in group apprentice training schemes which allow the apprentice to be moved from firm to firm so that a broad training is obtained.

My Institution will shortly issue "A Guide to Management" and this has been prepared as a guide to those who are concerned with the planning of practical training schemes for the professional production engineer.

A production engineer may practise in one of many industries and for this reason it has been considered inadvisable to set down any one special scheme of training : instead a set of general principles has been formulated which take into account the differences which will be encountered in each industry, product, organisation, and type of production.

Field of Activity for Production Engineering

Production in the sense that it is the manufacture of commodities and services embraces a wide field of activity and is concerned with the movement, forming and assembly of the complete range of known materials. The production engineer may tend to become a specialist in production in one particular industry or group of industries and his practical training may qualify him particularly for that group of industries.

Basic Objectives

For the production engineer to be fully equipped to deal with the practical problems he is likely to encounter, it is necessary that he should spend time within the industry or group of industries in which he seeks to qualify, so that the following basic requirements are met :-

1. direct experience of the manufacture of a complete product;
2. direct experience of the operation of a manufacturing organisation as a complete unit;
3. direct and personal experience of at least one or more specific production techniques;
4. direct experience and understanding of the function and attitudes of management;
5. direct experience and understanding of the function and attitudes of labour.

These are the basic requirements of any practical training scheme and they apply equally to all industries.

Standards

(i) The period considered to be necessary to enable all the foregoing principles to be properly covered is 24 - 36 months;

(ii) the combination of several works to provide an adequate training scheme is accepted as a desirable practice;

(iii) the type of production (and the extent to which that production is affected within the establishment) must be such that it is acceptable as being of a sufficiently wide content to enable the principles of production engineering and organisation to be adequately demonstrated to the student;

(iv) the works or organisation on which the training scheme is based must be such that the practices therein are up to the standard accepted by the Institution;

(v) the Institution accepts responsibility through its Standing Committees for approving practical training schemes;

(vi) a certificate of completion of the course is required for each student.

Elaboration of the Objectives

1. Direct experience of the manufacture of a complete product.
2. Direct experience of the operation of a manufacturing organisation as a complete unit.

This means that the student is required to have direct knowledge and understanding of the following aspects of production :-

(a) product design with respect to manufacturing;

(b) controlling and operating all manufacturing processes relevant to the product;

(c) engineering, providing and maintaining the means of production;

(d) controlling production;

(e) controlling cost of production.

(a) Through experience in the Production Design Department or its equivalent, he will understand the choice of material for the product and the various considerations which influence initial design with respect to manufacturing method.

(b) All manufacturing processes include moving operations, mechanical handling, forming and shaping operations, assembling and finishing operations, and inspection and testing. It is not considered necessary for the student to carry out all operations but he must have direct knowledge, which may be obtained through observation or practice.

(c) Providing and engineering the means of production refer to the location of the site, to the buildings, the plant, the machine tools and where necessary, the jigs and fixtures. Included also in this is the manufacturing and design of tools, the maintenance of the whole set-up and the provision of all relevant services.

(d) Controlling production in this sense is control of material used in production and not of labour. The production control system, stock control system, supply, both relative to the customer and to the supplier of raw and bought-out components, computing of information, progress, production planning, are all included in this group.

(e) Controlling the cost of production refers to all activities which assist in the control of cost of elements of production. Incentive schemes (which in the last analysis determine the cost of labour) estimating, cost control, general accountancy, and buying (not including the supply function) come within this section.

3. Direct and personal experience of at least one or more specific production techniques.

It is most important to have experience of one or more specific production techniques. Under normal conditions, in a mechanical engineering factory this experience would be obtained in the training school. Some knowledge of a basic craft such as turning, milling and fitting, would be obtained over a definite period and could well be an initiation period.

In addition to this basic training, which is essential, and which should be taught by a skilled craftsman, a specialist knowledge of an advanced production technique is also desirable. For example, six weeks on practical work relative to thread rolling, so that the student is able effectively to solve technical problems relative to the process is recommended. A qualified engineer should be able to produce evidence of several specialist experiences.

4. Direct experience and understanding of the function and attitudes of management.
5. Direct experience and understanding of the function and attitudes of labour.

The only practical way to obtain knowledge of the function of labour and its attitudes is to work with the operators and craftsmen themselves and to experience working conditions and problems in the working environment.

This implies a period of at least 12 months on the shop floor itself. This period may overlap other activities.

Management problems are best appreciated by working with persons in a supervisory capacity for a period. Specific study of the operation of the Personnel Department and attendance at Works or Shop Committees may also be practicable.

practical training associated with sandwich schemes

The Institution welcomes Sandwich schemes such as the Diploma in Technology since certification of the practical work performed is an essential part of the award and the National Council have just issued Engineering Industrial Training Certification Committees responsible for approving schemes of training in industry.

The general pattern is under three headings :-

(a) *basic training* preferably carried out in a Works Training School and covering processes which are basic and common to all types of engineering. Some degree of specialisation however is necessary, as for example, in electrical engineering.

(b) *Subsequent training* extends the basic into the areas of application and involves work on more advanced processes and equipment — also an appreciation of the economics of engineering.

(c) *Individual assignment training* is introduced towards the end to give increased responsibility and specialisation and is made possible by the student having acquired a knowledge of the fundamentals of engineering manufacturing activities by direct experience.

Fig. 5 shows the correlation of practical and academic training associated with the Diploma in Technology course at Birmingham College of Technology.

the universities

We have two schemes, the 1 : 3 : 1 and the 3 : 2.

The 1 : 3 : 1 student leaves the Grammar School at, say, 18 years, with all the necessary qualifications for University entrance, and obtains employment in a major firm. He receives for one year basic practical training, usually continuing his science and mathematics at the local Technical College on one day per week. He then spends three years in the University for his first degree, returning to the firm every long vacation for periods of carefully controlled practical training. After graduating the practical training is completed with a further year's work in the firm. This is popular with Universities, since the student is more mature and knows at least a little about factory life.

The majority of students, however, are of the 3 : 2 type who go straight from school to University and receive the whole of their practical training after graduation.

In neither case am I satisfied that the usual training is at all inspired. In all too few cases is the "specification" of a graduate considered. This can be simply :-

". . . has a sound knowledge of basic engineering sciences; can make and read simple drawings, do calculations and so on; should be able to read critically, argue logically and review facts analytically; has been working intellectually at a high pace for some years . . ."

A minority of firms working from this definition, and having clearly in mind the end product required, have superimposed on the more traditional practical training a series of exercises and projects. These are based on ideas supplied by the graduates' tutor—a man from middle or upper management and usually responsible for two graduates. I have been very impressed by some of the work I have seen and at the very least it, periodically, mentally stretches the graduate, gives him a sound knowledge of people in, and of, the organisation; makes a real, if small, contribution to the work of the firm and most important of all, ensures that the graduate and the firm eventually make a wise choice as to his subsequent activities.

the by-ways

I have now completed my survey of the two routes to professional production engineering, but it would be very foolish for the young engineer to pursue either a too narrow or too straight a course. In the transition from engineer to manager, the period from about 23 - 28 years is, I think, critical and success will largely depend upon the zest and skill employed by the young man in exploring the many by-ways which he will meet route-wise.

The training I have detailed should endeavour to foster the many personal qualities required and it may be appropriate to give a brief extract from Sir Walter Puckey's book "What is this Management?".

He gives the requirements of a manager as :-

"Must be capable of earning respect and of respecting other's views, of controlling personnel; of co-ordinating departments and individuals and himself; of distinguishing between opinion and fact; of defining and controlling the policy of a group; he must lead, not follow his subordinates; he must show results." He then goes on to give the required qualities :-

Personal 60% rating — clean living, strong commercial sense; good manners, sense of justice; good health; friendliness; cheerfulness; tolerance; a keen interest in personnel problems; recognition of the potential value in others; firmness; calmness in emergency; co-operativeness, courage; leadership or inspirational quality, clear cut and good speech.

Organisational 25% rating — ability to define the "objective"; ability to build a framework or organisation; ability to organise and co-ordinate the activities of personnel within the framework, analytical ability; and orderly mind; ability to delegate responsibility.

Technical 15%—basic training and practice in an appropriate technical subject; a sound appreciation of fundamental technical principles.

The difficulty perhaps lies in relegating the technical content of the manager's job to the low figure given by Sir Walter Puckey, and this possibly gives a clue to the uneasiness felt by many leading industrialists about this transition from engineer to manager. In short, it is desperately easy for the young engineer to set himself such a severe task of technical study that he neglects to equip himself for administrative responsibilities. He must avoid this danger by not getting confined to too narrow a technical front, and I believe the young production engineer must face up to moving about in industry after completing his formal training; by not always talking as an engineer, particularly as one who has lived in a compartment, let alone a department; by broadening his knowlegde of some of the modern aids to management, such as the

interpretation and use of quantitive data, ergonomics, cybernetics and others of like kin; by reaching out for responsibility and by broadening his knowledge outside the world of engineering by, say, travel (and other countries have so much to offer), and by an appreciation of some of the arts.

It is perhaps fitting that nearing the close of this lecture I dally a little in some of the more important of these by-ways.

post-basic training

I have little belief in long and formal studies for management occupying two or three evenings per week for a not inconsiderable number of years. I have already mentioned the very valuable short courses held in Universities and Colleges, but would also mention that there are many consultants in this field offering similar courses (the majority for Work Study). Mention must also be made of such as Ashridge, Sundridge Park and the Administrative Staff College; the valuable work being done by the British Institute of Management and to the courses organised and held in many major firms.

I would like to detail a course which was the result of co-operation between a major steel company and one of our largest consultant firms. The course lasts eight weeks, is residential, and is entitled "Productivity Engineering". It is designed for men already earmarked for specialist duties in the field of productivity improvement or managers requiring a deep appreciation of the subject. The syllabus falls into the main headings of: Work Measurement; Improvement of Production Methods and Procedures; Improvement of Planning and Management Controls; Wages Payment and Incentives; Techniques of Investigation and Communications; Industrial Relations.

In the field of teaching and training we shall shortly have a residential Staff College for senior teachers in educational institutes of technology and commerce and for senior industrial staff.

Perhaps more concerned with modern techniques are the British Productivity Council (B.P.C.) and the Production Engineering Research Association (P.E.R.A.).

British Productivity Council

This was formed in 1952 and is concerned with the improvement of the economic position of the country for the betterment of all. The Council comprises members from the British Employers Federation, Federation of British Industrialists, Trades Union Congress, Association of British Chambers of Commerce, National Union of Manufacturers and representatives for the nationalised industries. One hundred and six Local Productivity Committees endeavour to instill in the industrial community an attitude of mind favourable to raising productivity and modern techniques.

I am sure our young production engineer will attend at least some of the British Productivity Committe's lectures held in his locality.

P.E.R.A.

In 1939 the Institution established a Research Department to investigate specific problems, and spacious laboratories were made available at Loughborough College of Technology. The tremendous impetus given to production engineering by the Second World War made necessary the establishment of an entirely separate research organisation on a national scale. As a result the Government, through the Department of Scientific and Industrial Research (D.S.I.R.) and various industrial associations, established P.E.R.A. in 1946 at Melton Mowbray. Now, with a staff of 300 and some very extensive and excellently equipped laboratories it offers:-

(i) to develop better production techniques by practical research in P.E.R.A. Laboratories;

(ii) to assist firms with specific production problems as they arise in their workshops;

(iii) to supply members with information on the latest developments in production techniques throughout the world;

(iv) to secure the most rapid application of improved methods by liaison visits to members works, special training courses, practical demonstrations, etc.

Particularly in the field of education and training it offers:-

Five-day courses on metal cutting, methods improvement, inspection, metal forming, etc., for key industrial personnel.

A Mobile Unit for demonstrating improved production techniques, etc., at members' works.

Appreciation courses and conferences for Directors, Managers, etc.

A six-month course of advanced training in the development of production techniques.

Major Technical Colleges can now be affiliated members of P.E.R.A. and so obtain the information which I am sure is so necessary to keep the young engineer abreast with modern developments. For are we not in danger, in this era of almost explosive expansion, of teaching our young engineers techniques, which by the time they can apply them, will be largely obsolete? Most certainly I would ask you to keep this in mind when establishing courses in the Polytechnics. Flexibility is essential and there is a desperate need to see that teaching staff, in order to keep up-to-date, periodically move back into industry or engage in consultant work, and that high ranking industrialists give specialist lectures in their own field.

Whilst on this note, how better to conclude than by saying what my Institution has to offer, and what it endeavours to do for, the young production engineer.

conclusion

The Institution of Production Engineers

I should waste your time if I dealt at length on the advantages accruing to the ambitious young man by joining the professional Institution appropriate to his chosen career. In common with other institutions, junior members receive each month the Institution's Journal, *The Production Engineer*, which contains

articles and Papers on every aspect of production engineering and management over a wide range of industries, thus offering a rich background to their studies. In addition, junior members may attend all meetings of the Institution and take part in conferences and works visits.

The educational advisory services of the Institution's Headquarters and the Library facilities are also available to junior members.

To assist in the broadening of their training, that I consider so necessary, the Institution offers yearly a Travel Scholarship valued at £500 and tenable for a period of about six months in a foreign country. It offers to Graduate members of the Institution opportunities to obtain in other countries experience, both of production technology and human relations, which will obviously be of great value for their future careers.

I would however, pin-point the necessity for the young member to participate *actively* in the Committee work of his Graduate Section. Time simply *must* be found for Committee meetings, for arranging social activities and even for preparing an occasional Paper to be read to his Section. On our senior Committees such as Research and Technical, Education, Papers, Editorial, we owe much to those who started working for the Institution whilst still junior members.

To summarise, the Institution through its members and officers endeavours to see that the most promising of our engineering students will elect production engineering as a career, as upon them will fall the heavy responsibility of seeing that our export trade flourishes and that the reputation we have for quality is not only preserved but enhanced.

But having been so elected, the young man will receive in University or College and in industry, training that will enable him, in the words of Mr. J. C. George, C.B.E., M.P., "to transform the ideas of the designers into the hard substance of saleable products so that in addition to being a practical engineer, competent to make the best use of men, methods and materials, old and new, he must be something of an economist. He must also be alive to the possibilities not only of new production methods but also to new methods of fact-finding, control and communications which are among the tools of his trade.

"Clearly he must be a many-sided man—a sound technologist, a shrewd administrator capable of turning the plans of others into effective action, and able to translate technicalities into the simpler language of the workshop. He must also have an open mind towards the possibilities of change in methods and the use of materials, if he is to keep abreast of the times and be aware of what is happening outside his own factory."

This is the task we have set ourselves in Great Britain for the education, in its widest sense, of the young production engineer.

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ACKNOWLEDGMENT

Acknowledgment is made to Mr. T. B. Worth, Head of Production Engineering Department, Birmingham College of Advanced Technology for the loan of slides illustrating laboratories, etc., at the College.

CONTROL OF PRODUCT QUALITY

by H. W. MANDER, M.I.Prod.E.

Chairman of the Institution's
Sub-Committee on Control of Quality

THE considerable benefits to be derived from proper investigation into ways and means of achieving "The Prevention of Defects" is increasingly stressed by various organisations and in various Institution publications and conferences.

This short article is to reintroduce members to some of the aspects of the subject and also to encourage further action and stimulate correspondence through the medium of *The Production Engineer.*

As a result of increased interest the Research and Technical Committee, through the Control of Quality Sub-Committee, will, by various means, disseminate information and encourage action in a matter which is now widely recognised as a vital part of the work of production engineers.

a vital interest

There can be no professional man more vitally interested in quality than the production engineer. He is, in many cases, striving towards full control of production processes by the machine, which must eventually contain within itself the means of error correction. At the moment, however, he is faced, and will be faced for many years to come, with a combination of high productive equipment, insensitive to its own errors, fed and controlled by operators often motivated by the quantity incentive. Obviously, then, the production engineer must employ all necessary safeguards to ensure that the standard of quality required is in fact obtained, or accept the alternative of probably serious cancellation of his own efforts for increased productivity.

An inspector checks the work of operatives on a T.V. assembly line and endorses each operator's quality chart. A scene from the British Productivity Council's film "According to Specification".

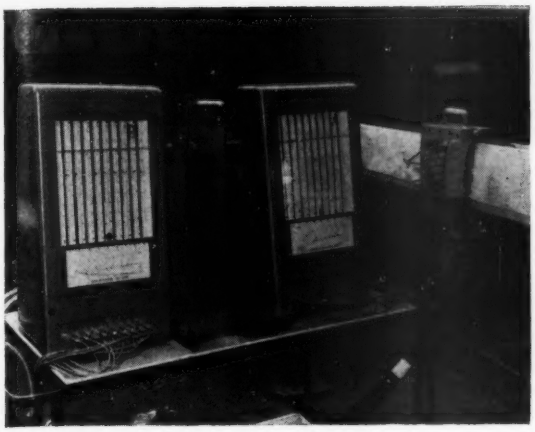
A recent F.B.I. enquiry indicated that while in the main, British industry was "confident of continual industrial expansion," 25% of firms surveyed stated that costs per unit have risen over four months and another 31% indicated that profit margins are down. It can be reasonably assumed that "quality" costs are one of the factors which should receive attention. The prosperity of this nation depends on overseas trade and in every trading field good and consistent quality is a welcome and saleable commodity.

It is significant that in many countries overseas, manufacturing organisations are adopting methods which make *big financial savings.*

"Value for money" is the final determining factor and unless careful precautions are taken, there is no more subtle and fatally easy way in which this value can be lessened than in deterioration of the required quality standard.

No less fatal, however, is addition to cost by the acceptance of a low standard of quality from the manufacturing process, and an endeavour to rectify the situation by the employment of sorting inspection and the subsequent throwing away or rectification of the unsaleable.

"Control of product quality at the point of production" or, more concisely, "The prevention of defects" is a philosophy which, carried into effect, can achieve actual cash benefits of a very substantial nature and, moreover, has the advantage of not requiring large capital expenditures for achievement.



An air gauge used to check 18 ordinates during hand finishing of external profile of metal helicopter blades. (Courtesy of Bristol Aircraft Ltd.)

Some of this philosophy was expounded in one of the Institution's best selling reports: "Quality — Its Creation and Control".*

Philosophy, however, needs to be translated into action to achieve results. Different organisations will adopt different methods; in the case of the small firm a few words from the "boss" will be sufficient, whilst in the large organisation it may require a more radical approach and the setting up of specialist action. The basic thinking, however, remains unchanged and functions which may be sub-divided in the large organisation may be a part-time job for somebody in the small one.

The Control of Quality Sub-Committee considers that members of the Institution will appreciate more detailed information on ways and means of effecting improvements of one type or another, and it is hoped to publish a series of articles giving the experience of several companies.

From market research through the stages of design, development, planning, manufacture, delivery and after-sales service, the vital ratio of quality (this includes, of course, reliability) and cost must be considered.

In covering the various fields of activity in later articles, it will be seen that before any action can be taken to improve the product quality there is a need for information to be collected to see where causes of trouble exist, so that the necessary action can be taken at the right place with the right effort and the information can be fed back to ensure that similar troubles are avoided in the future. This is the most important step.

Sir Simon Marks is quoted as saying:-

"It is easy enough to test goods when they are made. What is more important is to be sure that they will be well made from the start. What we want to have is process control and testing at the point of production."

present and future activities

The Institution's interest in Control of Quality goes back a number of years, when a Sub-Committee was formed as a result of a visit to America to study the subject of Quality Control. In 1958 the Institution published the report, "Quality — Its Creation and Control" which was an immediate success. As a result of this a Conference was organised in conjunction with the Institution of Engineering Inspection and the British Productivity Council, on "Quality in Industry". The Papers given at this Conference were published in the I.Prod.E. Journal.

The B.P.C. have also been active in this field and the Institution is represented on their Advisory Committee. In addition, the B.P.C. have arranged a number of seminars and courses on Quality Control and during these the film "According to Specification" has been presented a number of times.

A further development resulted from a conference held in Paris in 1955 by the European Productivity Association, from which the European Organisation for Quality Control was founded, and it was significant that Britain was one of the few countries which did not have some organisation for active promotion of Control of Quality techniques. An annual conference has been held by the E.O.Q.C. in each of the member countries and this year it was Britain's turn to act as host. An excellent programme of considerable value to industrial organisations, was drawn up, and the Paper presented to this Conference by Mr. Frank Nixon, entitled "The Value of the Control of Product Quality", is to appear in the November issue of *The Production Engineer.*

It is in this field of Control of Quality that The Institution of Production Engineers can, and must, take an active lead. It is not suggested that a new organisation be formed, but it is felt that active steps must be taken to ensure that the industrial techniques developed for effective control of product quality are expounded to the full.

Your Committee hopes to arouse wide interest in this subject and comments and suggestions will be very welcome.

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* Available from 10 Chesterfield Street, Mayfair, London, W.1, price 10s. per copy (postage and packing 1s.).

REPORT OF THE MEETING OF COUNCIL

21st July, 1960

THE first Council Meeting of the 1960 - 1961 Session was held at the Headquarters of the Institution at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 21st July, 1960. The Chairman (Mr. R. H. S. Turner) presided over a meeting of 29 members.

Before proceeding with the business of the Meeting, the Chairman said that he was very conscious of the privilege of taking office as Chairman of Council for the first time. It was a very onerous position and while he felt that he was not necessarily the best qualified man to undertake the task, members could nevertheless be assured that he would do his best.

It was the practice of the Council to invite Graduate Section officers to attend their meetings as observers, and it gave the Chairman much pleasure to welcome on this occasion Mr. W. G. Peters, Chairman of the London Graduate Section.

He had another very pleasant duty to perform and that was to welcome to the present meeting the President of the Australian Council, Mr. J. M. Steer, who was attending in his own right as a member of the Council.

Finally, the Chairman extended a welcome to newly-elected members of the Council, who were attending their first meeting.

Election of Standing Committees, 1960 - 1961

The report on the election of Standing Committees, which had been previously circulated, was received on the proposal of Mr. A. Betts-Brown, seconded by Mr. R. S. Clark. (The names of those elected to serve on the Standing Committees for 1960 - 1961 appeared in the September issue of *The Production Engineer.*)

Election of Section and Region Honorary Secretaries and Region Honorary Treasurers

On the motion of Mr. J. H. Winskill, seconded by Mr. R. S. Clark, the election of the above officers was confirmed.

Finance

The Council adopted the report on the Institution's finances for the year ended 30th June, 1960. Satisfaction was expressed that the Institution's excess of income over expenditure slightly exceeded the amount budgeted. The budget for 1960 - 1961 was also approved.

Future Institution Policy

The President (Mr. G. Ronald Pryor) advised the Council that he had for the past two months been discussing with the Principal Officers and the staff at Headquarters the Institution's future policy, and had prepared a lengthy memorandum on the subject. He gave notice, therefore, that this matter should be debated at the next Council Meeting in October, and it was agreed that this should be done.

The Summer Meeting

It was reported by the Finance and General Purposes Committee that the Conversazione held at the Royal Festival Hall on 27th June last, and which formed part of the Summer Meeting, was greatly enjoyed by those who attended. It was pleasing to record that this function, the first of its kind organised by the Institution, was highly successful and many complimentary letters and comments had been received at Headquarters.

Region and Section Honorary Secretaries Conference

The Annual Conference of Region and Section Honorary Secretaries, which was held at Headquarters in May, 1960, was attended by 22 Secretaries. Some lively discussion took place and the meeting agreed to adopt international paper sizes for an experimental period, in addition to approving new layouts for Section notepaper, tickets and posters.

Education

The Chairman of the Education Committee (Mr. W. G. Ainslie) drew the Council's attention, with regret, to the fact that two of the longest serving members of the Education Committee — Mr. E. Percy Edwards and Mr. J. France — had recently resigned. Between them they had a total of some 50 years continuous service on the Committee, and their wise counsel and sterling work would be very greatly missed.

The Council unanimously supported these comments, and asked that their sincere appreciation of this outstanding service be conveyed to Mr. Edwards and Mr. France.

Membership

The Council approved a number of applications for membership and transfer, details of which appear on pages 602 - 603.

The Journal

It was reported by the Chairman of the Editorial Committee (Mr. B. E. Stokes) that discussions were in progress with the Papers and the Research and

Technical Committees regarding the best means of publishing papers and other material dealing with production engineering research.

Institution Medal Awards, 1958 - 1959

The Council adopted the following recommendations, made by the Papers Committee, for the Medal Awards for 1958 - 1959:

Best Paper presented to a meeting by a Member: Mr. S. G. E. Nash, M.I.Prod.E., for his Paper presented on "Metallic Materials Development".

Best Paper presented to a meeting by a non-member: Dr. W. L. Kent, J.P., for his Paper on "Management of Men".

The J. D. Scaife Medal for the best Paper published in "The Production Engineer" (other than those presented to Sections or Regions, or Named Papers): Mr. C. J. Tanner, for his Paper on "Air Gauging — History and Future Developments".

The Papers Committee regretted that they could make no recommendation for The Hutchinson Award for the best Paper presented to a meeting by a Graduate Member.

Research

The following reports were received from the Research and Technical Committee:

Materials Handling Group

A Materials Handling Group has been set up within the London Section, under the Chairmanship of Mr. L. W. Bailey, and is already in active session.

Joint projects under the auspices of the National Joint Committee on Materials Handling are being pursued, but owing to their wide scope reports are unlikely to be available for some time to come. The Group Committee is considering a report on the Philosophy of Materials Handling, which it is hoped will be available by the end of this year.

Computers and Production Control

The report of the Sub-Committee should be available by December, 1960.

Control of Quality

As a result of the reconstitution of the Sub-Committee, a series of articles has been prepared and is being published in the Journal (see page 598). Through the Sub-Committee, the Institution was represented on the Programme Organising Committee of the Annual Conference of the European Organisation for Quality Control, held in London in September (see "Institution Notes").

Co-ordination of Production Management Techniques

The work of the Sub-Committee is progressing, but the implications of the subject are so wide that a certain amount of time has had to be spent defining the limits of the report.

It was further reported by the Research and Technical Committee that the two seminars recently held at Headquarters on "Operational Research" and "Factory Planning", and sponsored by the Committee, were highly successful and further meetings of this kind are being planned.

Standardisation

The Chairman of the Standards Committee (Mr. R. E. Mills), reporting on the Conference of Standards Engineers held in May last, and organised by the joint I.Prod.E./B.S.I. Standing Advisory Committee on the Use of Standards in Industry, said that an important outcome of the meeting was the decision to form an association to bring together those concerned with the application of standards in industry.

It had been agreed that no separate organisation should be set up, but that Standards Engineers and others with a special interest would be able to become associates, on a personal basis, of the British Standards Institution. That association had now been launched, and those members of the Institution who wished to join should apply directly to B.S.I.

The Library

It was reported by the Library Committee that an analysis of enquiries received during the past year revealed that the proportion of enquiries on technical subjects to those on managerial subjects was about 70 : 30. More enquiries were being received about materials handling than about any other single subject.

The Committee was continuing its work on the History of Production Engineering.

Liaison with Overseas Sections

The Vice-Chairman of Council (Mr. A. L. Stuchbery) reported that a number of visitors from overseas had been received at Headquarters during the past three months. They included Mr. A. E. Newcombe, a member of the Sydney Section Committee; Air Vice-Marshal Harjinder Singh, from New Delhi; Mr. J. M. Steer, President of the Australian Council; Dr. Sadakichi Shimizu and Mr. Motoi Nukina, representing the Japanese Consulting Engineers Association; Mr. Roger Waindle, Past President of the American Society of Tool Manufacturing Engineers; and Mr. Edgell, from South Africa.

There had also been a visit by 18 members of the Polish Society of Mechanical Engineers, with their Secretary, Mr. Jan Legat, and a visit to Poland of the Institution's Education Officer, Mr. F. W. Cooper, who had presented a Paper to The Polish Society of Mechanical Engineers and Technicians (see pages 578 - 597).

At the Chairman's invitation, Mr. Steer, President of the Australian Council, gave a brief address to the Council, in which he expressed his great pleasure at being present, and conveyed the greetings of the Australian Council and indeed all members of the Institution throughout Australia. He was very glad to report the steady rate of progress in Institution

development in Australia, and the visits of Mr. Harold Burke, Vice-President, and Mr. Woodford, the Secretary, had been especially welcome and helpful.

Mr. Steer also suggested that more publicity, through the medium of the Journal, might be given to activities in the Sections overseas, and it was agreed that the Council would certainly bear this in mind.

Secretary's Report on Commonwealth Tour

The Council received the Secretary's Report on his Commonwealth Tour (see pages 604 - 620). In presenting his Report, the Secretary said he had been on a goodwill mission, and he had intended to create goodwill. He had not felt it to be within his terms of reference to exercise his critical faculties unduly throughout the tour, at the expense of people who had gone out of their way to entertain him as the Institution's ambassador, and had arranged for him to make his tour as comprehensive as possible within the limits of time available. There might be some feeling that he had travelled about the world wearing rose-coloured spectacles, but he had deliberately intended to give this impression, for the reasons stated.

The Report contained a number of recommendations which were discussed at length by the Council, before being referred to the various Standing Committees concerned, for further consideration.

Obituary

The deaths of the following members were recorded with deep regret:

Members: Edward G. Brisch; Sir Francis Brake; S. Carlton Smith.

Associate Members: E. W. Allen; H. Binns; J. Hill; J. W. E. Brown; W. Worsley.

Associate: C. G. Heys Hallett.

Graduate: Basil A. Gay.

Student: P. B. Woodrow.

Next Meeting

It was agreed that the next meeting of the Council should take place on Thursday, 27th October, 1960, at 11 a.m., at 10 Chesterfield Street, Mayfair, London, W.1.

ELECTIONS AND TRANSFERS

21st JULY, 1960

BIRMINGHAM SECTION

As Member
E. F. Turner.
As Associate Member
W. A. Reynolds.
As Graduates
D. Hale; J. M. Gardiner; B. E. Heselton.
As Students
R. W. Huxley; J. Fawke; A. Farmer.
Transfers:
From Associate Members to Members
W. A. Parr; H. E. Robinson; C. L. Pyman; C. C. Cooper; J. H. Cross; B. E. Downs; E. N. Corlett; A. Crockett.
From Graduates to Associate Members
J. P. B. Ablewhite; D. R. Piper; J. Wale; D. G. Coleman; J. R. Brownsword.
From Student to Graduate
E. G. Salt.

BOMBAY SECTION

As Associate Member
L. Reis.
As Graduates
A. P. Mathur; M. M. A. Basha.
Transfers:
From Associate Members to Members
K. Singh; R. D. Mistry; C. R. Pal.

CALCUTTA SECTION

As Associate Members
L. N. Bhagwati; B. M. Sen.
Transfers:
From Graduates to Associate Members
G. P. Piper; S. Y. Jakatdar.

CANADA SECTION

As Students
J. D. Hubbert; J. R. Scott; D. A. Karsikas.
Transfers:
From Associate Member to Member
T. C. Greenhough.
From Graduates to Associate Members
I. A. Thomas; K. Barry.
From Student to Graduate
T. L. Hawkes

CARDIFF SECTION

As Graduates
J. W. Richings; W. A. M. Clarke.
As Students
T. E. Morgan; T. F. Wilson-Hooper; A. J. Paton; K. Jones; H. G. Jones.
Transfers:
From Associate Member to Member
A. Beard.
From Graduates to Associate Members
D. Evans; J. L. Noble.
From Student to Graduate
J. T. Banfield.

COVENTRY SECTION

As Member
R. A. Courtman.
As Graduates
B. Eyre; J. A. Furlong; J. B. Deveson; J. F. Cole; J. T. French; J. G. Crudgington.
As Students
K. E. Finch; F. R. Evans; C. K. Clark; C. H. Panting; D. J. Ashby; H. V. Sykes; R. M. J. Whitehead.
Transfers:
From Associate Members to Members
W. F. Webb; A. C. A. Johnson; R. J. Dixon.
From Graduates to Associate Members
D. G. Davies; M Clewley.
From Student to Graduate
B. D. Haggar.

DERBY SECTION

As Associate Member
J. R. Thompson.
As Graduate
J. E. Ashton.

DONCASTER SECTION

As Associate Member
R. J. Smith.

DUNDEE SECTION

As Associate Members
A. S. Fraser; R. D. Munro.
Transfer:
From Associate Member to Member
R. M. Douglas.

GLASGOW SECTION

As Associate Member
N. MacNicol.
As Graduates
J. L. Spence; J. A. Harris; A. J. J. Bird; H. D. Jackson; J. L. Harper.
Transfers:
From Associate Members to Members
J. C. Johnson; L. H. Osborne; W. Smith; G. C. Clark; E. H. Ingram.
From Students to Graduates
J. T. F. Evans; W. Cameron.

GLOUCESTER SECTION

As Student
J. E. Cloke.
Transfers:
From Associate Members to Members
W. A. Handley; R. Hayward.

HALIFAX SECTION

As Graduate
K. W. Young.
As Student
D. F. Marsden.
Transfers:
From Associate Members to Members
A. Richardson; F. Dolby.

IPSWICH AND COLCHESTER SECTION

As Member
T. W. F. Fishlock
As Student
M. R. Ison.
Transfer:
From Associate Member to Member
F. J. Woodall.

LEEDS SECTION

As Graduate
K. Mitchell.
Transfers :
From Graduates to Associate Members
From Student to Graduate
K. Tomlinson.
R. G. Wilbrey; N. P. Spencer.

LEICESTER SECTION

As Graduates
M. P. Callaghan; J. W. Frisby; B. Das; J. V. Harris; A. J. Summers.
As Student
D. Johnson.
Transfers :
From Graduates to Associate Members
F. Bond; G. V. Rosser; K. R. Newton; G. Akroyd.
From Student to Graduate
M. J. Cousins.

LINCOLN SECTION

As Graduate
C. E. Hampshire.
As Student
W. A. Osborn.
Transfers :
From Associate Members to Members
T. E. Burr; J. Kennan.

LIVERPOOL SECTION

As Member
R. A. Parkin.
As Associate Members
F. R. Brace; S. Price.
As Graduate
F. O. Gelder.
As Student
M. Darcy.
Transfers :
From Associate Members to Members
J. H. Barnard; R. W. Barraclough.
From Graduates to Associate Members
H. W. Curtis; R. F. Thomson; S. D. Allanson.

LONDON SECTION

As Members
A. W. Hall; F. S. Parry; S. J. Cox.
S. J. Cox.
As Associate Members
M. E. Rosner; S. W. Boyd; W. S. Stirrup; J. M. de Niet; R. F. Sharp; B. L. Winslow; R. W. D. Hookham; P. Parfitt.
As Graduates
T. A. MacLennan; M. T. Moore; C. C. Leighton; I. C. Taylor; D. J. Mansfield; J. C. Franey; L. Reynolds; N. W. Luland; C. L. Turner; R. H. Evans; L. A. Muriel; A. E. Wilcox.
As Students
R. C. A. Layton; A. G. Peters; K. A. North; J. R. Hunt; A. R. Crooke; K. Narasimhan.
New Affiliated Firm
Geo. Kingsbury & Co. (Machine Tools) Ltd.
Transfers :
From Associate Members to Members
W. H. Howes; R. E. Patmore; E. Fluke; W. T. Shiers; E. W. Kelsey; E. H. Revill; M. W. Hall; N. H. Soulsby; S. C. Welsh; R. C. Caunce; A. B. Merriam; F. W. Allen; H. Bamford Preston; C. N. L. Minister; R. D. Gaskin; R. F. Holland; A. E. Shinn; V. J. Morcombe; K. J. B. Dunn; N. Hope; A. E. Baxter; G. M. Dunn.
From Graduates to Associate Members
J. Tanner; A. Green; S. D. Hollander; B. Simms; A. F. Howard; P. M. Cockman; B. C. Jessop; K. A. Rutter; R. A. Durrant.
From Students to Graduates
T. F. Perkins; K. G. Jackson; R. V. King; R. C. Maxwell; J. R. Garlick.

LUTON SECTION

As Graduates
K. J. Akehurst; M. D. Darvell; F. C. Bull; P. S. Nixon; J. K. Colthorpe; W. Diack.
As Student
M. R. Beck.
Transfers :
From Associate Members to Members
D. J. Emms; T. G. Odell; R. A. Sibley; J. Keen; E. E. Weaver; A. H. Selby; J. E. Cook.
From Graduate to Associate Member
S. J. H. Wintle.
From Student to Graduate
L. J. Fisher.

MANCHESTER SECTION

As Associate Members
K. J. Clarke; H. Dearden.
As Graduates
A. P. Corkhill; R. C. Saksena.
As Students
G. R. Arnold; G. Downing.
Transfers :
From Associate Member to Member
F. Hodgkinson.
From Graduates to Associate Members
P. D. Pile; B. Lee.

MELBOURNE SECTION

As Member
H. G. Badger.
As Associate Members
R. S. Davie; D. Jones.
As Graduate
R. J. Granat.
As Students
J. York; G. A. Jennings.

NEWCASTLE UPON TYNE SECTION

As Associate Member
G. Winton.
As Graduates
W. W. Maddison; A. Bradley.
As Student
J. Lamb.

NEW ZEALAND SECTION

As Graduate
W. W. Henden.

NORTHERN IRELAND SECTION

As Member
M. D. Cleeland.

OXFORD SECTION

New Affiliated Firm
Wilkinson Sword Ltd.
Transfers :
From Associate Members to Members
R. Lamb; J. Bell; F. S. Chappell.

PETERBOROUGH SECTION

As Associate Member
J. Ellis.
Transfer :
From Graduate to Associate Member
K. Grant.

PRESTON SECTION

As Students
J. B. Dewhurst; J. Rushton.
Transfer :
From Graduate to Associate Member
A. A. Hardisty.

READING SECTION

As Graduates
A. W. Campbell-Dick; J. M. Burgess.

ROCHESTER SECTION

As Student
A. E. Perry.
Transfer :
From Associate Member to Member
W. S. Muffett.

SHEFFIELD SECTION

As Members
J. Durnford; J. P. M. Horsburgh.
As Associate
J. Bonsall.
As Graduate
G. E. Clewley.
As Student
B. C. Pagdin.
Transfers :
From Associate Member to Member
J. Ekins.
From Graduate to Associate Member
D. A. Stokes.
From Student to Graduate
B. W. S. Nuttall

SHREWSBURY SECTION

Transfer :
From Associate Member to Member
B. L. Steward.

SOUTH AFRICA SECTION

As Associate Members
K. V. Grivainis; A. T. Carnie; A. Brownlee.

SOUTHAMPTON SECTION

As Member
A. W. H. Sheppard.
As Associate Member
W. H. Guy.
As Graduate
B. T. Stroud.
Transfers :
From Associate Member to Member
H. Horne.
From Graduate to Associate Member
P. F. Deadman.

SOUTH ESSEX SECTION

As Member
S. A. P. Jackson.
As Associate Member
D. J. T. Panton.
As Graduates
J. R. Read; E. E. Labrum.
As Students
D. J. Potter; N. G. Smith; H. O'N. Eggecombe.
Transfer :
From Associate Member to Member
J. Trodden.

STOKE-ON-TRENT SECTION

Transfer :
From Student to Graduate
M. A. Leeke.

SWANSEA SECTION

As Graduates
D. B. Poole; D. R. Thomas; J. G. Williams

SYDNEY SECTION

As Graduate
S. A. Castelli.
Transfers :
From Graduate to Associate Member
D. C. Enderby.
From Students to Graduates
J. G. Campbell; E. W. Bishop.

TEES-SIDE SECTION

As Graduates
R. Holdsworth; N. M. Kilby.
Transfers :
From Associate Member to Member
J. L. Burbidge.
From Student to Graduate
C. J. Horseman.

WESTERN SECTION

As Associate Member
J. Lewis
As Graduates
J. Seaford; R. A. S. Getley; J. R. Allen; J. R. Butcher.
As Students
B. O. Jenkins; T. H. Harvey; W. P. Ure; M. J. Selway; D W. Ragbourne.
Transfers :
From Associate Members to Members
W. J. Latty; R. B. Muir.

WOLVERHAMPTON SECTION

As Associate Members
R. L. Redwood; E. D. Jenkins.
As Graduates
J. Cadman; A. Z. Onions; J. M. Oades; P. T. Evans.
As Students
J. A. Wilkes; C. T. G. Grainger.
Transfers :
From Associate Members to Members
M. G. Page; W. H. Cockerill; H. C. W. Trapmore.
From Student to Graduate
R. S. Evans.

NO SECTION

As Associate
U. Nnochiri.
As Graduates
N. K. Widhani; J P. Hayes; I. A. Sobhi.
As Student
N. R. Robinson.
Transfers :
From Associate Member to Member
A. G. McKay.
From Graduates to Associate Members
Z. A. Choudry; A. W. Pocock; E. Rath; J. Read

Report to the Council of

THE SECRETARY'S OVERSEAS TOUR

JANUARY — APRIL, 1960

1. APPRECIATION I should like to express my appreciation to all the many people who not only made the tour possible, but who contributed in so many ways to make it a very memorable journey. It was an experience the like of which I have never had before, and it was a great adventure. I travelled something of the order of 30,000 miles by air, and 4,000 or 5,000 miles by road and rail, and I saw people, conditions and country which are utterly different from those in the United Kingdom.

I am deeply grateful to the Council of the Institution for making this journey possible. My journey took me through Israel, Persia, India, Singapore, Australia, South Africa and Rhodesia. Wherever I went I was most warmly received by officers and members of the Institution and their ladies, who all extended to me the most generous hospitality. The Institution's officers and Committee members in these various countries had made the most carefully-considered plans to make the maximum use of my time, and to afford me the greatest possible degree of interest. Arrangements had been made for me to visit representative industries, industrial and labour organisations, university and technical colleges, and other teaching establishments, Government and State Departments, National parks and monuments, and many many other places of interest. I am greatly indebted to the Honorary Secretaries and Corresponding Members who were involved in so much detailed correspondence to ensure the smooth working of all these plans. I am grateful, too, to the managements, principals and officials of the many places I visited, for giving up their time on my account, and for extending to me so much hospitality. These visits were the very essence of my tour, and provided me with very rich educational experience. I learned more of the geography of the world — more of its industrial conditions, its economic and racial problems, its great distances and varied climates in the three months of the tour than in the whole of my previous life.

One of the lessons learned from the tour was the astonishing ease and speed with which it is possible to move about the world by modern transportation. In planning the tour, consideration was given to the maximum use of time, with a minimum of expense. It would, however, have been possible with the addition of only a few extra days, and at very little extra cost, to have visited the Institution's Corresponding Members in Rangoon and in West Africa, and also to have paid a brief visit to New Zealand. This should be borne in mind should a similar journey be undertaken in the future.

Although it may sound trite to say so, and may even amount to a cliché, the fact remains that a journey of this extent forces one to realise just how small the world is, and just how smug and self-satisfied a stay-at-home Englishman can be. Such a journey does not necessarily change one's views, but it inevitably very extensively broadens the outlook, and gives a much deeper understanding of the major world problems.

Finally, I should like to express my gratitude to all my colleagues at the Head Office of the

Institution, whose efficient administration of the Institution's affairs during my absence relieved me of all worry and responsibility.

It would be impracticable, and undesirable, for me to attempt to mention by name everyone to whom I am indebted in some way or another for their contribution to the intense enjoyment and richly-varied experiences of my tour, but to everyone, I express my deep thanks.

2. GENERAL IMPRESSIONS The most dominant impression which I formed during the tour was that there is an infinite future for the development of production engineering and for The Institution of Production Engineers — not only in the Commonwealth countries, but in other countries outside the Commonwealth. Nowhere did I find any organisation comparable with the Institution, nor providing any kind of service for engineers, scientists and technologists engaged in manufacture. Where institutions are established, they cater only for the older technologies: there is little realisation of the great potential future for the technology of manufacture.

The term "production engineer" is virtually unknown outside the United Kingdom, except within our own Institution circles. The term "industrial engineer" has been imported from America, and now has wide currency.

In the main, too, I found that in universities where industrial engineering is included in the curriculum, it generally follows the American pattern of dealing chiefly with the management techniques of production rather than with the manufacturing techniques of production.

There is, therefore, a splendid opportunity for The Institution of Production Engineers to expand outside the United Kingdom and to develop and offer a service for which a very great demand must surely arise in the near future.

To seize upon this opportunity, which will otherwise be taken up by others, will call for some change of thought within the Institution: it will be necessary for the Institution to adjust its thinking to suit Commonwealth and even world-wide conditions: it will be highly desirable for the Institution to regard itself as a Commonwealth or even world-wide organisation, which happens to have its Headquarters in London, rather than as a United Kingdom organisation which happens to have branches in Commonwealth countries and elsewhere.

It is worse than useless to attempt to impose English conditions in countries where they do not apply. In shaping its future policy, therefore, the Council of the Institution should consult more readily and more frequently with the officers and members in Sections outside the United Kingdom.

The Institution has a unique opportunity to contribute of its special knowledge to the development of manufacturing industries throughout the world. To do this, it must build up its membership in other countries, which will necessarily involve some adaptation of the rules and qualifications for admission. For example, there is little point in expecting an Australian candidate for membership to be familiar with trade union practices and working conditions in the United Kingdom: he is directly and personally involved in the trade union practices and working conditions of his own country.

I found everywhere great goodwill towards the United Kingdom, although some impatience was expressed here and there at the apparent off-handedness of some English suppliers. There was criticism of late deliveries, inadequate packing and protection for long journeys, indifferent — or in some cases even non-existent — after-sales service, and other minor points. Some Englishmen, too, have created a measure of ill-will when travelling abroad by giving the impression that everything which is English is therefore right.

I saw plenty of evidence that countries like Germany, Switzerland, France, Italy and Japan, are all moving into the Commonwealth countries and offering services in markets which have been traditionally held by the United Kingdom. By extending its membership in these countries, the Institution could influence the trend of thought and action, through its Journal and other publications, and by encouraging a free interchange of communications between members in different countries.

Experts forecast that the population of the world is likely to increase by 50% by the end of this century. The demand for consumer goods, and for the capital goods required to manufacture them, is likely to increase to a great extent in the same time. When one considers the phenomenal rise in the absorption of consumer goods, even in the United Kingdom, during the past decade, the assessment of the likely world increase in the next 40 years becomes a very difficult mathematical exercise.

The Governments of the more advanced nations of the world are all, by one means or another, as a matter of deliberate policy, hastening the development of the less fortunate nations. The rapid development and extension of the world's manufacturing resources to cope with

this vastly increased demand will create a great and ever-increasing demand for qualified production or industrial engineers and managers. It is significant to find that in Sydney, New South Wales, in spite of the fact that The Institution of Production Engineers has had a Section there for 24 years, the American Society of Tool and Manufacturing Engineers has recently opened a Chapter there which is rapidly gaining in membership.

The expansion of the world's economy — short of a major disaster such as another world war — will continue unabated. The Institution of Production Engineers can choose whether or not to play a part in this expansion.

3. RECOMMENDATIONS (This section of the Report contains a number of recommendations which are under consideration by the Council.)

4. ISRAEL In view of the fact that my route took me over the Middle East, I thought this would offer a good opportunity to meet Mr. Merkine, who is the Institution's Corresponding Member in the Middle East, and at the same time to see something of developments in Israel since it ceased to be the British-mandated territory of Palestine. Mr. Merkine had made careful and thoughtful arrangements on my behalf, which enabled me to get a very good perspective of developments in this new country.

The places and organisations visited were as follows :

1. The National Manufacturers' Association.
2. The permanent (but ever-changing) exhibition of Israeli industrial products.
3. The Association of Architects and Engineers in Israel
4. The Israel Productivity Centre.
5. The Israel Standards Institute.
6. The National Federation of Labour (the Histadruth).
7. The Weitzmann Research Institute at Rehovoth.
8. The new Hebrew University at Jerusalem.
9. The Israel Institute of Technology at Haifa (The Technion).

The deepest impression left upon me as I ended my visit to Israel was the feeling that everywhere there was a very strong sense of common purpose, linked to a great sense of urgency. Everyone seems to be imbued with the feeling that their first responsibility is to the development of their country, and that any attempt to press for purely personal advantage is anti-social. Relations between employers and employed, both at personal level and through their organisations, appeared to be very friendly and co-operative. There has been no national strike in the history of Israel : the longest strike of any kind was one of only four days' duration in a particular works, and this was over some minor problem of working conditions. One factor which may considerably help labour relations in Israel is the fact that the dominant labour organisation, which is the Histadruth, is also an employer, since the Histadruth owns large industrial enterprises. There are no separate trade unions in Israel comparable with those in the United Kingdom : the Histadruth has separate departments dealing with the various trades and kinds of employment.

I was very impressed by the high standard of manners and courtesy, which are everywhere evident. Smiling faces predominate, and one has a strong feeling that Israel is a happy country.

When the United Kingdom gave up the mandate in 1947, the population of Israel was then 500,000 people. At least one Royal Commission, and numerous other experts, had said that Israel was a barren waste incapable of supporting more than the then population. Today the population of Israel exceeds 2,000,000, and vast areas of what was thought to be barren desert have been brought into cultivation. Schemes of irrigation, fertilisation and afforestation are being pressed forward all over the country, and it was very impressive to see, for example, orange groves in full fruit on land which 10 years ago was thought to be desert.

I saw an interesting factory for the processing of oranges, in which the most modern plant has been installed. The oranges are automatically peeled, the peel then travels down one line, and the fruit down another ; the pectin and volatile oils are extracted from the peel ; the juice is extracted from the fruit ; the resultant pith from both the peel and the fruit is then composted and converted into fertiliser, and ultimately returned to the soil.

The industrial economy in Israel is based on the principle of added value. There are virtually no industrial raw materials in Israel, so rather than import raw materials and then go through all the process of conversion, the present policy is to import semi-finished goods, or goods finished but completely knocked down, and then to finish or assemble. Part of the goods are retained for home use, and a proportion is exported. Israel is developing healthy export markets, and there seems to be a possibility here for United Kingdom manufacturers to establish assembly plants in Israel, and then export to markets which normally would not be available to Britain. As the economy expands, complete manufacturing units will be established, and in some industries—for example, tyre manufacture — this is already being done.

The old University of Jerusalem fell into the hands of the Arabs when Jerusalem was divided at the Armistice. Israel has therefore been forced to build a completely new University at Jerusalem, and very great progress has been made. A group of completely modern buildings has been erected on a hillside ; very advanced styles and techniques of architecture have been employed, and great use has been made of local building material, particularly some beautiful pink-veined marble.

The University of Jerusalem is concentrated mainly on the humanities, pure sciences and medicine ; little or no engineering is done there. Applied science and technologies are dealt with at Haifa, at the Israel Institute of Technology, known as the Technion ; this is a technical university which can be compared in some ways, I suppose, to the Massachusetts Institute of Technology, and some of the Colleges of Advanced Technology in the United Kingdom.

The Technion is being rapidly expanded, and some magnificent new buildings have been constructed. There is a school of production engineering, and work was just beginning on the buildings for production engineering whilst I was there. The school at present is in the charge of two American professors, and on the whole they are concentrating more on the techniques of the management of production rather than on the technology of production. The general feeling there is that the technologies are properly dealt with in the schools of mechanical, electrical, chemical and aeronautical engineering.

I had valuable conversations with Mr. Merkine on the general trend of Institution development, and found him to be keenly interested and full of ideas. He feels very strongly that the Institution should develop a dynamic policy of world-wide expansion.

In Israel, there is little or no official interest in production engineering. The only professional body is the Association of Architects and Engineers, and this body is dominated mainly by civil engineers and by architects, who, of course, in a great expansion programme, wield considerable influence

I had the pleasure of a meeting with the Chairman of the Mechanical Engineering Section of the Association, but found him to be little interested in the development of the technology of manufacture. As the population of Israel grows, and with it the momentum of their industrial development, there will be great scope for The Institution of Production Engineers. One can see ample possibilities of flourishing Sections of the Institution, both in Tel-Aviv and in Haifa ; but this development will be completely frustrated unless some modification of the membership regulations is made to admit as members candidates with Israeli qualifications. This is not to suggest any lower standard ; indeed the standard of education in Israel is extremely high.

It is likely that in the near future, a steady stream of production engineering graduates will be flowing from the Technion at Haifa. It would be highly desirable that graduates in production engineering of the Technion should be immediately eligible for election to the Institution, so far as academic requirement was concerned.

Among other suggestions which Mr. Merkine made was a proposal that the Institution should develop a world-wide documentation service ; the Institution would gather together sources of information about production engineering developments throughout the world, and make them available to members in abstract form. A code of ethics might be established, and the Institution, in co-operation with other appropriate bodies, might publish codes of standard practice and data ; the publication of synthetic data in tabular form was also suggested.

Israel is a thoroughly Westernised country ; all the habits and manners, and dress, follow the Western style. The official language of the country is Hebrew, but English is universally used. For example, all the street names are printed in the two languages. The sight of English letter-boxes on street corners gives one a pleasant feeling of being at home, and everywhere one sees evidence that the British occupation has left indelible marks on the country.

My brief stay in Israel was a rich and inspiring experience. Mr. Merkine was a very pleasant and well-informed companion and guide, and I am deeply grateful to him for making my visit so intensely interesting and enjoyable.

5. INDIA My journey from Israel took me via Teheran, where I had a brief rest; via Karachi to change aircraft, and thence to Bombay, where I was met at the airport by Mr. Alec Miller, Chairman of our Bombay Section, and Mr. Raymond Misra, a Past Chairman. The Bombay Section Committee had arranged the following visits for me:

1. Premier Automobiles.
2. Mukand Iron and Steel Works.
3. The New Standard Engineering Co. Ltd.
4. The Crescent Iron & Steel Corporation.
5. The Aary Dairy Colony, for the improvement of the Indian cattle.
6. The Kanheri Caves and National Park.
7. The Ambarnath Technical School and Government Ordnance Factory.

I attended a Section Committee meeting, a full Section meeting at which I gave an address, and a Section dinner which was given in my honour.

My guides throughout my stay were Mr. Miller and Mr. Misra, together with members of the Section Committee, and their profound knowledge of India and Indian affairs was of immense value.

During my journeys to and from the various organisations which I visited, every moment of the time was fully employed in learning as much as possible about the industrial and social conditions in India. I found Bombay to be everything I had expected: a large and thriving city, densely populated; a strange mixture of architecture, customs and dress; very hot and humid. I stayed at the Taj Mahal Hotel, a very large and ornate building looking something like St. Pancras Station, London, but where the service was impeccable.

During my stay, the celebrations for Republic Day took place, and this was an unforgettable experience. The whole city was decorated with electric lights, and not only were all Bombay's 4,000,000 people in the streets, but millions more poured in from all the outlying villages. The sight and sound of the multitude defies description. They moved through the streets at great speed — many actually running — and every conceivable kind of vehicle was pressed into service: lorries, trucks, hand-carts, horse-drawn Edwardian carriages, buses, cars, bicycles, tandems, barrows and bath-chairs, all flowed along the streets in a never-ending stream, six to ten abreast, at 10 miles an hour. All the time, pedestrians dashed to and fro among the vehicles, so that it seemed they must surely be crushed to death, until they emerged again safe and sound on the other side. Everyone seemed to be deliriously happy, although the strongest drink available in prohibition in Bombay was sugar cane juice, which boys on the sidewalk dispense by the simple process of passing the ripe cane through an old kitchen mangle. The noise was tremendous — not loud so that it hurt the ears, but simply overpowering in its intensity.

I did not visit any educational establishments, as Sir Walter Puckey and Mr. Cooper had just completed their visit to Bombay, and had dealt with this aspect of our interests. Sir Walter and Mr. Cooper had made a deep impression, and their visit did an enormous amount of good.

My meeting with the Bombay Section Committee was a most valuable one, and we had full and frank discussions on many aspects of Institution development. The two problems which were then in the forefront of their minds were the proposal to increase the membership subscriptions, and the qualifications for membership.

The Bombay Section Committee were very uneasy about the effect which increased subscriptions might have on recruitment. However, after a lengthy discussion, they agreed to accept the new rates on the understanding that they would be reviewed in the near future if the effect should be as they feared.

The qualifications for membership were a much deeper problem. The view was very strongly expressed that Indians are educated in India, to work in Indian industrial conditions at Indian rates of pay, and if the Institution was to take advantage of the possibilities which lay before it in India, then it was pointless to insist upon United Kingdom qualifications. If the United Kingdom conditions are enforced, then the membership in India is likely to be confined to European engineers working in India, and to those very few Indians who are able to come to Europe for their education.

I attended a full Section meeting in Bombay, where I gave a short address on the history and development of the Institution, its current policy

and future aspirations. Afterwards, I was very closely questioned on a wide range of subjects.

The Section Committee also gave a dinner in my honour, which was held in the gardens of the Willingdon Club in Bombay; this was a most pleasant occasion, and it was an enjoyable experience to dine out of doors in such beautiful surroundings.

From Bombay, I visited Bangalore in the Southern half of India, where, I had been told, there were great prospects for the establishment of a new Section of the Institution. I had an introduction to Colonel Chakravarthi, the Director of an important branch of the Indian Royal Engineers, established in Bangalore; he is also the local Honorary Secretary of the British Institute of Radio Engineers, and I was introduced to him through Mr. G. D. Clifford, the Secretary of the British Institute of Radio Engineers in London. Colonel Chakravarthi had very kindly called a meeting in his office of a number of leading industrialists, to discuss with me the possibility of establishing a Section of the Institution in Bangalore. I found that we already had a small group of members in that city, and Mr. G. N. Advani, of Hindustan Aircraft Ltd., kindly agreed to act as temporary Honorary Secretary during the formation stages of the new Section. Mr. Advani also acted as my guide and friend during my two or three days in Bangalore, and I enjoyed his company immensely.

The contrast between Bangalore and Bombay is dramatic. Whereas Bombay is filthy, dusty, hot and humid, every inch of space utilised, dense traffic, millions of people, appalling slums side by side with magnificent buildings, with beggars and princes cheek by jowl; Bangalore is a garden city, full of beautiful gardens and flowers, open spaces, fine buildings, virtually no slums, drier than Bombay, and — when I was there — 10 to 15 degrees cooler. Bangalore, historically, is the seat of Government of the State of Mysore, and until recently a purely administrative and judicial centre; during the last 10 years, however, the Indian Government has made substantial industrial development around the city: modern factories have been erected, and the population has increased from about 750,000 to nearly 1,500,000. The factories have been built more or less in a ring around the outer perimeter of the city, and new housing estates for workers and executives have been built with them. The range of products includes aircraft and aircraft engines, railway rolling stock, machine tools, electronic and telephone equipment, glassware and ceramics, electric lamps, and so on. Several factories are very large, employing 5,000 people and more.

I met and had talks with most of our few members in Bangalore, and I met and gave an address to the Bangalore Institute of Management.

Through Mr. Advani's kind offices, I was able also to visit about half-a-dozen of the main industrial plants. The General Manager of Hindustan Machine Tools Ltd., Mr. Patil, is an old member of the Institution, but he was unfortunately indisposed during my visit, so I was unable to see him. However, I found his deputy, Mr. Iyer, an extremely able and enthusiastic man, who very kindly agreed to lend his support to the foundation of the new Section.

An interesting feature in Bangalore is an establishment known as the Industrial Training Institute, where full-time residential courses in the mechanical crafts are provided. This is a Government establishment, and the course consists of 18 months full-time instruction in the Institute's own shops and classrooms, followed by six months further training in local factories. There is a minimum entry standard roughly equivalent to a General Certificate of Education at O-level, and the Institute accommodates 450 resident students. As an indication of the growing interest of Indians in industrial and mechanical development, for the last intake of 200 students into the Industrial Training Institute, there were 4,000 applications, ranging in age from 16 to 25 years.

The Principal of the Institute is a very competent and likable man; he had been trained in the British Service, and had risen to supervisory rank before being appointed as Principal of the Institute.

I enquired in local industry about the quality of the output, and received very favourable comment. At Hindustan Machine Tools, Mr. Iyer, the Deputy General Manager, said that he found that only six months further training was necessary to bring the trainees from the Institute up to the standard of skill required for precision machine tool work.

Hindustan Machine Tools' factory was originally laid out by Swiss engineers, and most of the production machinery is Swiss. Production was originally planned for an output of 400 machine tools a year, mainly radial drills, grinding machines, planers, millers, lathes, etc. Already, after five years operation, output is at the rate of 750 machines per annum, and a new factory extension is now being built, which it is hoped will increase output in the near future to 2,000 machines a year.

I saw many Hindustan machine tools in use in some of the factories which I visited during my

tour of India, and everywhere I heard them spoken of in the highest praise.

I formed the impression in Bangalore that there was scope for a large and flourishing Section of the Institution there, and I am sure that with the enthusiastic work of Mr. Advani and Mr. Iyer, great progress will be made.

I was entertained in the homes of Mr. and Mrs. Advani and of Mr. and Mrs. Iyer, and I am most grateful to them for their generous hospitality.

Once again I should like to record my gratitude, not only to Mr. Advani and Mr. Iyer, but to Colonel Chakravarthi, for all his efforts on my behalf; and also to Colonel Kapoor, a very old member of the Institution, of Hindustan Aircraft (Engines Division), who gave me much help and advice.

From Bangalore, I returned to Bombay, where I had another meeting with the officers of the Bombay Section, to report to them on my Bangalore activities. The Bombay Committee agreed to act as parent Section to the proposed Bangalore Section. Then I moved on to Delhi for a brief visit, where I met and had a talk with Mr. Dance, of the United Kingdom Ministry of Education, who is seconded to Delhi to assist in the development of higher technological education in India; and for a meeting with Professor Thacker, who is the Secretary for Scientific and Cultural Affairs to the Government of India. I found Professor Thacker very sympathetic to the aims and objects of our Institution.

Although the present policy of the Indian Government is intensely nationalistic, with a great reluctance to recognise any non-Indian bodies, I found Professor Thacker very receptive to the idea that official recognition should be given to The Institution of Production Engineers. The proposed inauguration of an Indian Council, which would provide a national centre for the Institution, greatly encouraged Professor Thacker, who readily appreciated that the Institution could do a great deal to assist in the development of Indian industrialisation.

From Delhi I flew on to Calcutta where I was met by Mr. Goodchild (a Past Chairman of the Calcutta Section) and Mr. O'Leary (the Honorary Secretary). During my stay in Calcutta, I was the guest of Mr. and Mrs. Goodchild in their flat and I am most grateful to them for making me so welcome and for extending to me such warm hospitality.

Visits had been arranged for me to:

1. The Jay Engineering Company.
2. Bengal Potteries.
3. The Tata Iron & Steel Company.
4. Tata Engineering & Locomotive Company.
5. Burn & Company.
6. Guest, Keen & Williams.

The manufactures in these plants include sewing machines, electric fans, domestic pottery, iron and steel, locomotives, heavy road vehicles, railway rolling stock, railway points and crossovers, nuts and bolts, motor car wheels, steel railway sleepers and lines.

I attended a meeting of the Calcutta Section Committee and also a Dinner given for the Committee in my honour by Mr. Gupta, the Chairman. I also attended and spoke at the Calcutta Section Annual Dinner which was held during my visit. Again, the two problems which chiefly concerned the Section Committee were the effect of the increased subscriptions on recruitment and the qualifications for membership.

After I had explained to the Section Committee the development of the Institution's financial affairs over the past 10 years or so, they loyally agreed to accept the new rate of subscription on the same understanding as in Bombay, viz.: that they should be reviewed again at a later date when their effect had become evident. I also had a full discussion with the Committee, as I had had also in Bombay and with the members in Bangalore, on the establishment of an Indian Council. There was considerable enthusiasm for this proposal and a draft Constitution and Terms of Reference were agreed. It was originally thought that the inaugural meeting of the Indian Council might be held during my visit but, on reflection, it was decided that it would be a better plan to hold the inauguration in Delhi a little later when Sir Walter Puckey would be returning via India after his visit to Australia to take part in the International Management Congress. These plans eventually came to fruition and the Council was inaugurated in Delhi on 26th March, 1960. The details of the inauguration have already been reported to the Council and published in the Journal.

During my stay in Calcutta, I was flown to Jamshedpur in one of the Tata Iron & Steel

Company's private aircraft, accompanied by Mr. Goodchild. Whilst in Jamshedpur we were the overnight guests of the Tata Company. I was asked to receive a delegation of about 20 young graduate engineers who were very interested in the Institution and who expressed the wish to have a Section of the Institution formed there.

The city has a population of about 400,000 and has a number of very large industrial enterprises. The city is more or less owned by the Tata Company and its Associated Companies. At the Steel Works' Headquarters there is a very fine modern lecture theatre which will seat about 100 people, which the Company very kindly offered to place at the disposal of the Institution for meetings, or as the Headquarters of a Section if one is formed there. The Calcutta Section Committee undertook to foster development in Jamshedpur with the object of establishing a Section there as soon as practicable.

I am quite certain that there are immense possibilities for development of the Institution in India. With its vast population and potential market for consumer goods, as the Government policy of raising the standard of living slowly takes effect, one could look forward to a time when the number of members of the Institution in India could easily exceed the total number in the United Kingdom. The extent of industrialisation at the moment is not much more than scratching the surface. The appalling poverty of the bulk of the population is a forbidding obstacle. There are many inhibitions to progress caused by religious practices and age-old customs which will take many many years to change. But these changes undoubtedly will take place and with them will come an ever-rising demand for the products and benefits of civilised life. After 200 years of British rule, a mere dozen years of independence has already wrought great changes.

I was deeply impressed by two factors which will greatly influence progress. Firstly, I found that the best of Indian top managers are men of the highest calibre judged on any standards. They are all anxious to learn and to apply the best modern management practices in their factories and they have an insatiable thirst for technological knowledge. They are beginning, too, to accept the view that a period of practical training in the factory is an essential ingredient in the training of young managers. I met several groups of young graduate engineers who fairly exhausted me with their endless questions!

The second factor which impressed me is the great aptitude for industrial skilled craftsmanship which many Indian workmen exhibit. Indians are craftsmen by tradition, as is evidenced by the inexhaustible store of works of art and craft which can be seen in the shops and bazaars. I saw evidence, for example, at the Ambarnath Technical School, that carefully planned and supervised practical training can produce highly-skilled Indian craftsmen. It is in these twin fields of skilled management and skilled craftsmanship that the Institution could contribute so much to the development of India and help to lead India to a full realisation of her immense potential resources.

In developing the Institution in India, great care must be taken to respect the Indians' desire to develop their independent status. Indian members must be encouraged to take office and to run the Institution's affairs, with United Kingdom members acting very much in the background as guides, philosophers and friends.

Everywhere I went in India I was received with the greatest courtesy and respect and I found on all sides a very warm and genuine affection for Great Britain.

My visit to India, although it lasted a brief three weeks, was a rich experience and I very much hope that some time in the future I may be able to visit again the many friends I made there.

6. AUSTRALIA The next stage of my journey took me — via Singapore, Jakarta and Darwin — to Sydney, New South Wales, where I was met by Mr. Cecil Curtis, the Chairman of the Sydney Section; Mr. Eldred Bishop and Mr. Sam Downie, Past Chairmen of the Section.

During my first week in Australia, I was the guest at the home of Mr. and Mrs. Sam Downie and, at the week-end, of Mr. and Mrs. Eldred Bishop. I am most grateful to them for extending me such warm hospitality.

The Sydney Section Committee had made the most careful plans so as to give me as wide a picture as possible of life in Australia. Coupled with visits to factories and educational establishments were tours of Sydney and the surrounding country. Visits were arranged to:

1. The Australian Institute of Management (Sydney Division).
2. The National Standards Laboratory.
3. The University of New South Wales.

4. The Australian Iron & Steel Company at Port Kembla.

5. Lysaghts' Springhill Works at Port Kembla.

6. James N. Kirby Holdings (Pty.) Ltd.

7. Amalgamated Wireless (Australasia) Ltd.

8. The Government Small Arms Factory at Lythgow.

I attended a meeting of the Section Committee; two meetings of the Education and Membership Sub-Committee; a dinner party given in my honour by the Section Committee, at which no less than six Past Chairmen of the Sydney Section were present; and also addressed a full meeting of the Section when I was asked to speak on: "The Institution's Attitude to Education for Production Engineering at Professional Level".

In Sydney, as also in Melbourne and in Adelaide, I found that the major preoccupation was with membership and the qualifications required. The Australian Council and the three Sections had already considered the increased membership subscriptions and agreed to accept them. Their proposal was that they should accept the full United Kingdom rate of subscription, since they were organised on a Section basis and offered members much the same service as in the United Kingdom, but that the subscriptions should be payable in £A as had been the practice for some years past.

Nowhere in Australia was the suggestion made that professional standards should be lowered, but there was a very strong feeling that the qualification should be much more flexible and adapted more to local conditions. The point was very strongly made that applications for membership should be considered, as it were, "in the round" and that the definition of a production engineer, contained in Article of Association No. 6, should be more broadly interpreted, i.e., that the Membership Committee should be concerned with the candidate's competence as a production engineer having regard to his complete background and that shortcomings in any particular direction should be offset by excellence in other directions. The Australian members, too, would like to see some provision for admission to membership, even if in a sub-professional or non-qualified grade, of members who are practising successfully as production engineers but do not and are not likely ever to have the qualifications for professional membership. There are many such men in Australia who are being attracted to join the American Society of Tool and Manufacturing Engineers, a body which does not call for any professional qualification of membership but provides much the same kind of background of activities and interests as does the Institution. Their Journal, too, is a very attractive publication. Although there is a strong feeling in Australia that the Institution's demands for academic requirements are somewhat out-of-step with the other requirements of membership, they nevertheless fully appreciate the need for adequate academic background. Indeed, in Sydney this had occasioned some differences of opinion between the Section Committee and the appropriate Departments at the University of New South Wales.

The University of New South Wales is a new University developed entirely for technology and it has taken over much of the work previously done by the Sydney Technical College. A Department of Industrial Engineering has been established under Associate Professor Hill, who has recently toured extensively abroad studying developments in industrial engineering. The course, as it is at present developed, consists of two years' study of basic science and technology and two years' study of the management aspects of industrial engineering. The Sydney Section Committee had recommended to the Education Committee in London that this degree course should not be recognised as exempting from the Institution's examination requirements, since it contained insufficient production technology.

In developing the course, the Dean of the Faculty of Engineering, Professor Willis, together with Professor Hill, had consulted a wide variety of industries in Australia to find their needs. They had also studied the Institution's own publications over a number of years and read all the various papers and articles which had been published by us on the subject of "Education for Production Engineering".

It was as a result of these studies that their course was planned and they were somewhat annoyed when the Institution declined to give recognition to the course. I spent some time in consultation with the authorities at the University and with the Sydney Section Education and Membership Sub-Committee, and we were able to resolve the difficulties and to re-establish friendly relations between the Sydney Section of the Institution and the University of New South Wales. The present situation is that the Education Committee in the United Kingdom have accepted my

recommendation that the course in industrial engineering at the University of New South Wales should be given provisional recognition for a period of, say, four years.

Professor Hill informed me that it was his intention to introduce into the course a number of electives which would be devoted to various aspects of production technology. It is thought likely that, as these electives become established, they will meet the Institution's criticism of the weakness in production technology in the course and that eventually the provisional recognition can become established as full recognition.

It is essential that the Institution should establish a close working liaison with the University of New South Wales since they are setting a pattern which is likely to be followed in other parts of Australia. The term "industrial engineer" is widely used in preference to the term "production engineer" and all universities which I visited (New South Wales, Melbourne, Adelaide and Brisbane) are showing a marked interest in its development.

In addition to the degree course in Sydney, the University of Melbourne has a full professorial chair in industrial engineering (Professor Henderson) whereas, in both Adelaide and in Brisbane, industrial engineering is a part of the Department of Mechanical Engineering but, in both these two latter universities, interest in manufacturing techniques is rapidly growing and it is thought that in the fullness of time, professorial chairs will be established at both universities.

There is great enthusiasm for the Institution in all the Australian Sections, but there is a strong feeling of frustration among the older members, who have worked hard for so many years to build up the strength of the Sections, that their efforts are now being frustrated by the too stringent qualifications for membership. I was glad to be able to draw attention to the revised rule for top members which now allows direct election into full membership under Article 14(c) at the age of 35. This has given great encouragement to the Sections in Australia which, because it is still a young country industrially, has many young men getting into the higher ranks of management.

I suggested to them in Australia that they would be better advised for the time being to concentrate on building up their Section membership at the top level and to allow the junior membership to grow at its own rate, as the facilities for getting the appropriate academic qualifications expand.

It was a very great pleasure to me to renew again acquaintance with various Australian members of the Institution who had visited the United Kingdom during the past years. I was overwhelmed by their hospitality and their warm friendliness. Our Australian members were especially appreciative of the Council's decision to send me on this visit. They always welcome senior members of the Institution and are grateful when these visiting members attend Section Committee meetings or give addresses to the Section but, on the whole, visiting members are primarily concerned with their own business affairs and do not have a great deal of time for the Institution. The Australian Council and Sections were especially appreciative that, on this occasion, they had a visitor whose time was entirely at their disposal.

During the second week of my stay in Sydney, I was a United Kingdom delegate to the 12th International Management Congress which was held this year in Australia — the first week being in Sydney and the second week in Melbourne. In this Report I will not elaborate on the C.I.O.S. Congress. It followed the usual pattern of these Congresses, with which most members will be familiar. The outstanding feature of the Conference was the way in which it had been organised by the Australian Institute of Management. There were altogether about 2,000 delegates in the Conference and the administrative arrangements were excellent.

It is pleasing to record that a number of senior members of our own Institution are very active also in the Australian Institute of Management and played a leading part in the organisation of C.I.O.S. XII. It is pleasing to record, also, that the United Kingdom made two outstanding contributions to the Congress; in both cases by the Earl of Verulam, who was the leader of the United Kingdom delegation.

Lord Verulam's Paper on "Organisation, Decision-making and Communication, and their Relationships" was considered on all sides to be one of the best Papers presented throughout the Congress. Later on, at the Congress Banquet in Melbourne, Lord Verulam again made a major contribution in that his speech in response to the Toast of "The Health of Overseas Visitors" was outstandingly brilliant and brought the whole gathering of 1,200 people to their feet in applause.

The programme of the Conference and the text of all the Papers presented is available in the Institution's Library for any member who would care to borrow them.

During the week-end between the two halves of the Congress, when the delegates were moving from Sydney to Melbourne, arrangements had been made for a very small party of overseas visitors to pay a visit to the Snowy Mountain Hydro-Electric and the Water Conservation Scheme. I was fortunate enough to be one of the 50 members lucky in the draw and found this visit to be a very inspiring experience.

The Snowy Mountains are a part of the Great Dividing Range which runs almost the whole length of the eastern side of Australia quite near to the coast. The Great Dividing Range throughout most of its length does not rise much above 4,000 feet and there is therefore very little snow but, in the Snowy Mountains, they rise to more than 5,000 feet and one peak — Mount Kosciosko, which is the highest peak in Australia — rises to over 7,000 feet.

There is a geographical peculiarity in that the western, or inland, side of the Snowy Mountain Ranges is extremely steep and, therefore, holds very little snow, whereas the eastern, or seaboard, side has a number of plateaux and gentle slopes intersected with deep valleys, which hold a very great deal of snow. Unfortunately, however, every Spring, with the rapid thaw, the bulk of this snow-melt rushes straight out to sea and is lost.

The essence of the Scheme is that a number of the deep valleys should be dammed so as to trap the snow-melt, which will then be diverted by tunnels right through the mountain to the west or inland side and fed into the Murray River and the Murrumbidgee River which together travel 2,000 miles across Australia before joining the sea near Adelaide. In passing through the mountain, the water is being utilised to drive power stations. During the three-day visit to the mountains, I was privileged to see the work at all stages of development. I saw some of the dams which had been completed; dams half finished and others only just beginning. I went underground and visited power stations built in the heart of the mountains and into some of the tunnels, the longest of which is 14 miles. Engineering-wise there is nothing exceptional about this Scheme. The power stations are conventional power-engineering and the tunnels are conventional mining, but one is lost in admiration of the conception of the Scheme and the intensely imaginative planning which has taken place.

I had the pleasure of a meeting with Sir William Hunter (the Head of the Authority responsible for the Scheme), who gave a very interesting address on its development to the C.I.O.S. party. When the Scheme is fully developed in a few years' time, it will bring great benefits to Australia. Not only will it supply abundant cheap electrical power over a very very wide area, but it will also feed into the rivers desperately-needed water which, with irrigation, will enable large additional areas of land to be brought under cultivation. The shortage of water in Australia is a problem which can really only be fully appreciated when one is on the spot. For example, I visited the pleasant town of Whyalla in the State of South Australia. This flourishing town of 10,000 people has been built mainly to exploit the rich deposits of iron ore which lie 30 - 40 miles inland in a range of hills bearing the appropriate names of Iron Knob, Iron Monarch and Iron Baron. Whyalla is a sea port and has a flourishing shipyard, building high-quality ships mainly for transporting the ore. There are a number of factories including one of C. A. Parsons & Co. Ltd. (the famous Newcastle-upon-Tyne firm), and a fully-integrated steel mill is now in process of erection. It comes as a shock to realise that the nearest source of fresh water to this town is the River Murray, *nearly* 250 *miles away* — almost from London to Holyhead. Every drop of fresh water has to be brought to Whyalla via overland pipeline which, in the course of my journeys, I was able to follow from the pick-up point at the River Murray right through to its emptying point in the reservoirs at Whyalla. Rain only falls in the area of Whyalla during about two months of the year and most of this rain is lost by rapid drainage into the sea. Various attempts at boring for water have been made but, always, only salt water has been found below the surface of the land. This is typical of the kind of natural obstacle which Australia has to overcome in her industrial and pastoral development.

At the conclusion of the Snowy Mountains visit, I flew on to Melbourne to rejoin the C.I.O.S. Congress. I was met at the airport by Mr. Steer, the President of the Australian Council, who extended to me the same warm welcome as I had received in Sydney. I must confess that, during the remaining days of the C.I.O.S. Congress, I played truant from the Sessions a good deal in order to meet as many members as possible and to get to know other people in Melbourne preparatory to my second week there which was to be devoted entirely to Institution affairs.

During my stay in Melbourne, I had meetings with members of the Education and Membership Committee; with the full Section Committee; I also addressed a full meeting of the Section and attended an all-day meeting of the Australian Council of the Institution, which was held in

Melbourne during my visit. Visits were paid also to:

1. The University of Melbourne (Professor Henderson — Professor of Industrial Engineering).
2. The Royal Melbourne Technical College (Principal — C. McKay).
3. The Healesville Nature Reserve in the Dandenong Mountains.
4. A Government Ball Bearing Factory at Echuca.
5. Irrigation Works on the River Murray.
6. Government Ordnance Factory at Bendigo.
7. The Fler Furniture Company.
8. The Heritage Furniture Factory.
9. The International Computers and Tabulators (Melbourne) Factory.
10. McPhersons Ltd.

My meetings with the members of the Section Committee and the Education and Membership Committee followed much the same lines as in Sydney. Again, I found a strong preoccupation with the qualifications for membership and the difficulty of recruitment of new members. I drew the Committee's attention to the new provision that full Members of the appropriate standing can be introduced at the age of 35 and impressed upon them the importance of building-up the membership in the higher levels as an immediate programme.

The facilities for production engineering education are more widespread in Victoria than they are in New South Wales and they follow more closely the United Kingdom pattern. There are a number of well-established technical colleges, of which the Royal Melbourne Technical College is probably the most outstanding, and in most of these good work is being done in production engineering.

At the University of Melbourne there is established a professorial chair in Industrial Engineering, headed by Professor Henderson who is a good friend of the Institution.

The members of the Committee accepted the view that it would be a serious mistake to lower the academic standard and other requirements for junior members and they readily accepted my suggestion that greater strength in the ranks of senior members would eventually have the effect of encouraging the juniors to make the effort to become qualified to join.

The full-day meeting of the Australian Council was a very enjoyable and useful occasion. Members of the Council had travelled to Melbourne from both Sydney and Adelaide and there was a fully-representative meeting. We discussed in great detail the whole background of the Institution's affairs; its current development; recruitment policy; programme planning; choice of principal officers; the organisation of the Australian Council's finances; and many minor points. The Australian Council were especially appreciative of this opportunity to have such a detailed discussion of the Institution's affairs with its chief executive officer and they strongly expressed the hope that opportunities for similar discussions should take place from time to time over the years.

At the conclusion of the Australian Council Meeting, Mr. Steer, on behalf of the Council, presented me with a beautiful model Koala made from natural fur as a souvenir of my visit. This was a singularly appropriate gift since the Koala, of course, is found nowhere else in the world outside Australia and New Zealand.

There is a very great loyalty to the Institution in Australia, which is overlaid for the moment by a keen sense of frustration at their inability to make sufficiently rapid progress in terms of recruitment of new members. I believe, however, that the ability now to elect full Members from the age of 35 will be especially helpful in Australia where, with young and rapidly developing industrial environment, promotion to senior positions comes early to able men. Even if the qualifications for membership remained exactly as they are now, I am certain there is considerable scope for expansion of the membership in Australia in the higher ranks of industry.

The close liaison which exists between the Institution and the Australian Institute of Management is a most valuable one which, I hope, will continue to be fostered and further developed.

The Institution is indeed fortunate to have its affairs in Australia directed by such keen and able men, many of whom hold very high industrial positions. I believe the chief value of my visit was the full and frank discussions I was able to have with so many leading members which, I am sure, have helped to clear away much of the feeling of frustration from which they were suffering.

An outstanding feature of my stay in Melbourne was a two-day tour which had been especially arranged for me by Mr. E. J. W. Herbert, the Melbourne Section Chairman, who is

Controller of Ordnance Factories for the Commonwealth Government. This tour, which was made by car with Mr. Herbert as host and guide, took us right across the State of Victoria to the River Murray, which is the border with New South Wales. We travelled for some length along the Murray looking at water conservation projects and land development and returned via another route to Melbourne. During the course of this trip we visited two Government Ordnance Factories, old mine workings and numerous places of interest. Mr. Herbert was a delightful companion, extremely well-informed on all aspects of Australian history and development and current affairs. I am particularly grateful to Mr. Herbert, not only for the very careful thought and planning which he had given to this tour, but also for devoting so much of his time to me during my stay.

I had the pleasure, too, of a meeting with Mr. LeCheminant, who is now living in retirement in Melbourne (although still very active!) and who will be remembered by many old members of the Institution.

I spent a delightful day with Mr. and Mrs. Ray Deutsher and their two children touring in Dandenong Mountains and, at the end of my stay, I spent an extremely pleasant and restful week-end with Mr. and Mrs. Steer in their home.

Strong pressure was brought to bear on me, both in Sydney and Melbourne, to visit Brisbane and renew my acquaintance with Professor Mansergh Shaw, Professor of Mechanical Engineering at the University of Brisbane.

My travel schedule allowed me an interval of two days between Melbourne and Adelaide, so I utilised this time to pay a flying visit to Brisbane, which proved to be very well worthwhile. In Brisbane, I met and gave an address to members of the Brisbane Division of the Australian Institute of Management and spent a day with Professor Shaw and his colleagues at the university. Within Professor Shaw's Department of Mechanical Engineering, there is growing a strong interest in production engineering and Professor Shaw devotes a good deal of his time to this rapidly developing branch of his work.

The university is beautifully sited on a small hill which dominates a great curve of the Brisbane River. The handsome group of buildings which, although following traditional lines of architecture yet embodies many modern features, can be seen from many vantage points at a great distance away. The engineering block is still in course of construction and, for the time being, Professor Shaw's department is occupying old buildings in the city.

Industrially, Brisbane is not so far developed as either Sydney, Melbourne or Adelaide, but development is taking place and one can foresee that Brisbane will be the next place for the establishment of a Section of the Institution in Australia.

From Brisbane I flew, via Sydney, to Adelaide where I was met by Mr. Harry Baker, the Section Chairman, and Mr. Fred Penny, a Past Section Chairman. The following visits in and around Adelaide had been arranged for me :

1. Rubery Owen & Kemsley (Pty.) Ltd.
2. Tecalemit Ltd.
3. Pope Industries Ltd.
4. The Housing Trust of South Australia.
5. The University of Adelaide.
6. The Electricity Trust of South Australia's new Power Station at Port Augusta.
7. Iron Ore Workings in Whyalla and the Iron Ore Handling Installations in the Port of Whyalla.
8. Broken Hill (Pty.) Shipyard at Whyalla.
9. The Whyalla Factory of C. A. Parsons Ltd.
10. Seppelts Winery.
11. Kelvinator Ltd.
12. General Motors (Holden's) Ltd.

I attended a meeting of the Adelaide Section Committee who also gave a dinner in my honour, and also addressed a full Section meeting which was held jointly with the Adelaide Division of the Australian Institute of Management. The State of South Australia, although very thinly-populated, is rapidly developing and the Government is taking very vigorous action to promote the welfare of the State.

I was taken on a conducted tour of a completely new town named " Elizabeth " (after H.M. the Queen) which had been built by the Housing Trust of South Australia. This new town — 17 miles from Adelaide — is naturally rather raw at the moment, but extensive plantings of trees is being carried out which, as the buildings mature, will help to make a very pleasant town.

This new town is not just a cluster of council-type dwellings. A variety of different styles has

been employed; larger houses for executives, smaller ones for the less well-off, houses for sale and houses to rent, pubs, hotels, shopping centre, children's play centre and a community centre have all been incorporated in the plan.

A depressing feature of the town from an English point of view is that all the buildings are bungalows, which gives a great air of flatness, especially as the town has been built on a piece of completely flat country. It is proposed, also, to develop light industry in the area to provide local employment.

The State Government is prepared to offer very attractive terms to manufacturers who wish to establish plants at Elizabeth and there is obviously very considerable scope for development in the area. Mr. Kevin Phillips, a member of the Trust's staff was my guide on this occasion and I found him very well informed and an enjoyable companion.

Mr. Baker, the Section Chairman, had, like Mr. Herbert in Melbourne, arranged a tour for me which took me deep into the country. During this tour, which included the visits to Port Augusta and Whyalla, I was to experience several violent changes of climatic conditions. As we travelled outwards from Adelaide, the temperature rose to 110 degrees and there was a very strong hot wind blowing. We were overtaken by a vast dust storm of the kind one often reads about but rarely experiences. The dust is so fine that it hangs in the air like a thick fog. The experience was not unlike being in a "pea-soup" London fog except that instead of being a murky yellow the "fog" was of a deep reddish pink and the temperature, instead of being near freezing point, was well above 100 degrees! We motored for an hour through this dust storm and the visibility was often down to 20 yards. It was exceedingly uncomfortable but a very interesting experience. When the storm passed, the whole country was blotted out by a film of dust.

As we drove in to Whyalla we were greeted by a violent thunderstorm which brought with it torrential rain — the first which had fallen in the area for nearly a year. Within a few minutes of the storm beginning, the whole place appeared to be running with rivers of tomato soup as the rain washed away a year's accumulation of the thick red dust which settles everywhere during the long dry spells. The following morning, after the storm, the countryside had taken on a completely changed appearance. Everywhere the dull red monotone had given way to bright fresh greens and new grass sprung into life overnight as if by magic.

Much of what is thought to be desert in Australia is not desert at all but is quite fertile land, but the total absence of water for such long periods makes it unable to sustain growth except of the sparsest kind.

During this tour, I visited the shipbuilding yard at Whyalla, the ore-handling installations of Brocken Hill Pty., both at the docks and in the quarries, 30 or 40 miles inland. I also visited the Whyalla factory of C. A. Parsons and, at Port Augusta, a new power station recently brought into commission by the Electricity Trust of South Australia.

At Whyalla, where I was the guest of Brocken Hill Pty., I was entertained in the homes of Mr. and Mrs. Muller and Mr. and Mrs. Pool, which contributed much to my enjoyment. I had the pleasure, too, of being entertained by the Port Augusta Rotary Club, who paid me the compliment of making me the guest of honour for the evening.

Whilst I was in Adelaide, an International Festival of Art was being held, somewhat similar to the Edinburgh Festival, which had attracted to the city many celebrities of international repute and visitors from far and wide. As part of the celebrations there was a floral festival when literally every building, lamp-post and, indeed, any object which would serve, was decorated and festooned with flowers. It was a brilliant and breathtaking display and one wondered at the great industry and patience which had produced such a mass of sparkling blooms in an area with so little rainfall, which must be heartbreaking from a gardener's point of view.

I spent, too, a very pleasant day touring and picnicing in the ranges of hills which stand behind Adelaide with Mr. and Mrs. Baker and Mr. and Mrs. Coombes and their families.

My tour in Australia officially ended in Adelaide; from there I was to fly to Johannesburg via Perth.

What an interesting experience this visit to Australia had proved to be. Populated originally by Englishmen and full of English habits and customs and tricks of speech, it is nonetheless utterly different from England in its climate, in its industrial conditions and in its pastoral development. It is a country with infinite possibilities in the future. The basic problem of aridity would seem to be well-nigh insoluble, but a few years ago it was likewise thought impossible to put objects into orbit in space. When Australia's problem of water shortage has been solved, as I am sure eventually it will be, then she will rapidly become one of the richest countries in the world.

7. SOUTH AFRICA I flew on to Perth for an overnight stop and a brief rest, prior to flying to Johannesburg for the last leg of the tour. The flight from Perth to Johannesburg, roughly 6,500 miles, was mostly over the Ocean, with stops for fuel at Cocos Island and Mauritius. It was a very hazardous trip and involved no less than four turn-backs! The first was for a cyclone which raged down the west coast of Australia and held up all flying in both directions for 24 hours; then we had engine trouble; and then two lots of compass trouble! I eventually arrived in Johannesburg 49 hours late to be met by Mr. Mogford, the Chairman of the South African Council, Mr. Aitken, the Secretary, and members of the Council, who entertained me to a belated but very enjoyable luncheon at the airfield.

My delayed arrival had occasioned some changes of programme — the loss of two days visit causing considerable inconvenience to various people. I had originally intended to spend a couple of days in Rhodesia meeting some of our members, especially in Bulawayo, but, as I had made no firm arrangements this plan was abandoned, and the two days were added to the end of my Johannesburg visit so that, in fact, the full programme as planned was carried out but in a different order. The following arrangements for visits had been made:

1. The Witwatersrand Technical College and Trade School.
2. The University of Witwatersrand.
3. The Council for Scientific and Industrial Research, and other Research Foundations.
4. The South African Bureau of Standards.
5. The Production Engineering Section of South African Railways at Pretoria.
6. The Rand Great Easter Show.
7. The East Daggafontain Gold Mine.
8. Rand Engineering Pty. Ltd.
9. National Bolts & Rivets Ltd.
10. Stewarts & Lloyds at Vereeniging.
11. The Vecor Works at Vereeniging.
12. Central Engineering Works.
13. Wilkinson Manufacturing Company.
14. The Witwatersrand Native Labour Association.
15. African Explosives & Chemical Industries Ltd.
16. The South African Iron & Steel Corporation.
17. Central Organisation for Trade-Testing.

A meeting with the South African Council; a full Section meeting, at which I gave an address; and, finally, a two-day visit to the Kruger Park National Game Reserve completed my programme. Throughout the visit the weather was superb — brilliant sunshine from a cloudless sky almost the whole time — but, at 6,000 feet, the average altitude in that part of Africa, there was a cool breeze which made conditions very comfortable. It is a tragedy that such a beautiful country should be torn by such bitter disputes. The Government policy of apartheid, the trade unions' attitude to native labour, the Afrikaner's attitude to non-Afrikaners, the Dutch Reformed Church and its attitude to the Anglican and other communities; every aspect of life is affected: politics, religion, industry, farming and leisure pursuits. I thought it little short of miraculous that in these conditions people could remain so calm as they generally are except for occasional outbursts.

In my travels in the Transvaal, I saw no evidence of trouble and there was little or no noticeable feeling of tension. One travelled around as freely and as easily as at home. I was very well received wherever I went. I had the opportunity of many meetings, including luncheons and dinners with many influential people in Johannesburg, Vereeniging and Pretoria. Johannesburg was one of the few places I found around the world where the use of the term "production engineering" has been current for some long time. It will be recalled that the Institution's Council was established when the former South African Association of Production Engineers merged with the Institution. Many of the old members of the South African Association still play an active part in the Institution's affairs and are serving on the South African Council of the Institution.

My meetings with the Council came at a most opportune time. I found that they had, in a sense, failed to grasp the full significance of the

Institution's changes of thought and policy in the past decade and the idea of broadening the base was but little comprehended. The South African members still considered that production engineering was mainly confined to metal cutting and very little attempt had been made to recruit members from outside this field. There are, however, great possibilities for recruitment in other industries.

Again, I found, as elsewhere, a major preoccupation with the inhibition to recruitment imposed by the present qualifications for membership. But, as in Australia, I found that the South African Council had not fully appreciated the very recent change in the Membership Regulations which permitted the election of full Members from the age of 35. I urged upon the South African Council the importance of concentrating their recruitment for the time being at this level. Even during the course of my brief visit I met a number of very senior people who were well qualified to join the Institution immediately as Members but it had not occurred to our South African members to attempt to interest them in membership. Even in the field of traditional metal working engineering, there are very large enterprises in South Africa very thinly represented in the membership.

I realised, too, that although many of the members of the South African Council are themselves in the senior ranks of industry, they had not fully grasped the significance of the very important management content in the modern development of production engineering and they were not seriously looking towards the ranks of top management for recruitment. We had a very lively and outspoken discussion on this subject and the South African Council undertook to re-examine their membership policy in the light of changing conditions.

My visit to the Witwatersrand Native Labour Association was a most enlightening experience. In this organisation 3,000 native labourers are recruited every day. They are drawn from many places outside the Union of South Africa and they are directed to work mostly in the mines and similar organisations. They are fed, they are clothed, their medical wants are attended to, they are trained and they are given contracts of service varying from 9 to 18 months.

In my visit to the East Daggafontein Gold Mine, when I went underground to the working face, I saw much of this labour actually in operation. I will make only one comment, which to me is most significant: with native labour recruited outside the Union of South Africa (that is mainly from Rhodesia, Tanganyika, Kenya, Nyasaland and Mozambique), at the end of his contract of service, in spite of arduous, even gruelling, physical labour for eight hours a day underground, every labourer records an increase in his weight of not less than 14 pounds, the average being an increase of 20 pounds during the space of one contract.

So far as The Institution of Production Engineers is concerned, I am satisfied that the same prospects of future development prevail in South Africa as they do in Australia and in India. The Institution itself is not a party to any of the disputes; indeed, by the very nature of its constitution, it could in some ways contribute to a solution to some of the problems.

My visit to the Kruger Park National Game Reserve was an exhilarating experience. I was the guest of Mr. and Mrs. Hugh Goyns and their son, Alaster, and we travelled by car from Johannesburg to the National Park some hundreds of miles across the Veldt — both the High Veldt and the Low Veldt. Mr. Goyns kindly planned a circuitous route to show me as much as possible of the country. How different everything was from what one had imagined! One thinks always of Africa as the "Dark Continent" and this, I suppose, gives one the impression of a gloomy place. Nothing could be more untrue. The wide open country, rolling hills, sparkling sunshine are anything but gloomy. The gloom in South Africa exists only in the mind of man. Mr. and Mrs. Goyns have made a very deep study of the natural life and history of South Africa; they were, therefore, splendid guides and companions.

The Kruger Park is an enormous area of wild country which has virtually been sealed off from civilisation. The only roads are dirt tracks cut through the bush and the Park is an area of some 300 miles from north to south and varying from 30 to 60 miles from east to west. In this Park all nature lives in a free and unfettered state, protected only from their worst enemy — mankind. Dotted about the Park are camps built like native villages within an animal-proof compound. One is compelled to book in to the camps before sundown and one is allowed out only at sunrise. When travelling through the Park travellers must remain within their cars, windows must be closed and open cars are not allowed. The animals are accustomed to motor vehicles and know that they have nothing to fear from them and so they ignore them. Consequently, an expert guide like Mr. Goyns was able to take me to the haunts of numerous animals and it was very thrilling to see them thus in the wild state. I was made to realise the importance of the rules when on one occasion

a family of baboons clambered all over the car. One was indeed able to enjoy all the thrills of the chase without the necessity of indulging in any killing!

The Secretary of the South African Council, Mr. Andrew Aitken, and Mrs. Aitken, accommodated me as their guest in their home at Bryanston, near Johannesburg, throughout my stay, and I am most grateful to them for their generous hospitality and warm welcome. I was thus afforded the opportunity of having long talks with Mr. Aitken about the Institution's future plans with special reference to development in South Africa.

The South African Council gave a farewell dinner for me at which I was presented with a handsome silver salver as a memento of my visit.

When the time came for my departure from Jan Smuts Airport at the end of my mission, I had the strong feeling that this journey has been well worthwhile; it enabled me to forge links between the Headquarters of the Institution and many members in distant parts of the world, which I am quite certain will be for the eventual benefit of the Institution. I am more than ever convinced that the future holds infinite possibilities for the Institution throughout the world. A world-wide extension of the Institution's membership would not only contribute to the establishment of a new bond of friendship between Great Britain and other countries, but it would also enable the Institution to spread far and wide the principles of production engineering and industrial economy, which are the very essence of its being.

Correspondence

From : **E. N. Corlett, A.M.I.Prod.E.,**
Senior Research Fellow,
Department of Engineering Production,
University of Birmingham.

Batch Production

Most of British industry is operated on a batch production basis but the amount of knowledge of the principles behind batch production is small compared to the flow or mass production situation. Under the sponsorship of D.S.I.R. and S.A.T.R.A. a research project has recently been initiated in the Department of Engineering Production, University of Birmingham, to investigate the basic principles of the economy, psychology and control of batch production. The initial stages of this work involve some extensive surveys of the present situation in a number of factories and in different industries. Parallel with this it is necessary to conduct a wide survey and analysis of the control methods used in batch production factories and it is for this latter work that we would like to enlist the help of members of The Institution of Production Engineers.

We have prepared a questionnaire covering the functions normally included under production controllers and would appreciate a large number of firms to volunteer to fill this in for us. We also require a copy of each form used for production control. In return for this information we would, if the firm so wished, eventually supply them with an analysis of their form utilisation, indicating where overlapping or ambiguities occurred, together with a summary report on the control situation throughout the industry. All the information supplied would, of course, be kept as confidential and would not be identifiable to individuals or firms in the reports.

From : **Cecil F. Hurst, M.I.Prod.E.,**
Deputy Chairman and Technical Director,
Samuel Osborn & Co. Ltd., Sheffield.

The Management Burden

I should like to congratulate the Editor on the publication of the Fifth Elbourne Memorial Lecture given by Harold Wilmot, C.B.E., entitled "The Management Burden".

It is to be hoped that this Paper will be widely read and absorbed, as the principles Mr. Wilmot has laid down can be of the utmost value, particularly to the young men who are in training and are being developed for the management function.

Many of the principles laid down by Mr. Wilmot have been applied in this Company for many years and have proved to be the basis of good relationships within the organisation.

It has been very pleasing to see the subject of management dealt with so excellently in this Paper.

"Controlling Product Quality" — E.O.Q.C. Conference

THE European Organisation for Quality Control held its Fourth Annual Conference this year in London, on 1st - 3rd September, on the theme "Controlling Product Quality — Its Value to Industry". The Conference was organised by the British Productivity Council, who are the British representatives on the E.O.Q.C.

Over 600 delegates from 17 countries listened to 11 Papers covering all aspects of Quality Control, from management responsibilities to improving the operation of a chemical plant by evolutionary methods. The Papers were presented by authors from seven countries, including U.S.A.

Institution representation

The Institution of Production Engineers was well represented on the Conference Planning Committee, the Chairman of which, Mr. F. Nixon, M.I.Prod.E., is this year's President of the E.O.Q.C. He is also a member of the Institution's Control of Quality Committee.

The Conference was opened by The Rt. Hon. F. J. Erroll, M.P., Minister of State, Board of Trade, and he was supported by Sir Bertram Waring, D.L., Chairman and Managing Director of Joseph Lucas Ltd., and Deputy Chairman of The British Productivity Council.

"Quality from the Viewpoint of Management" was the subject for the first session, the Chair being taken by Mr. G. Ronald Pryor, the Institution's President. Session Two covered "The Problems of Reducing the Cost of Inspection"; Session Three: "Diagnosis of Trouble in Manufacture"; and Session Four: "New Concepts in Quality Control".

During the proceedings of the second day, a presentation of a hand-made crystal goblet was made to one of the world pioneers of scientific quality control, Dr. B. P. Dudding, of Great Britain.

Presidential reception

The Institution, in view of its considerable interest in Quality Control, and the active part which it had taken in the planning of the Conference, arranged a Presidential reception for overseas visitors, on Friday, 2nd September, at its Headquarters in 10 Chesterfield Street. Also present at the reception were leading members of the Institution and of the Research and Technical and Control of Quality Committees. Mr. G. Ronald Pryor also represented the Institution at a Government Reception given for the delegates on Thursday evening, 1st September.

The Institution became actively interested in Control of Quality in 1956, and a Sub-Committee of the Research Committee was set up to prepare a report, which was published in 1958 entitled "Quality — Its Creation of Control". This was followed by a national Conference on "Quality in Industry," held at Buxton, in June, 1959.

The Sub-Committee was re-formed in 1960 to further consider activities in this field and it is hoped that articles in the Journal, seminars and conferences will keep members of the Institution in touch with modern developments.

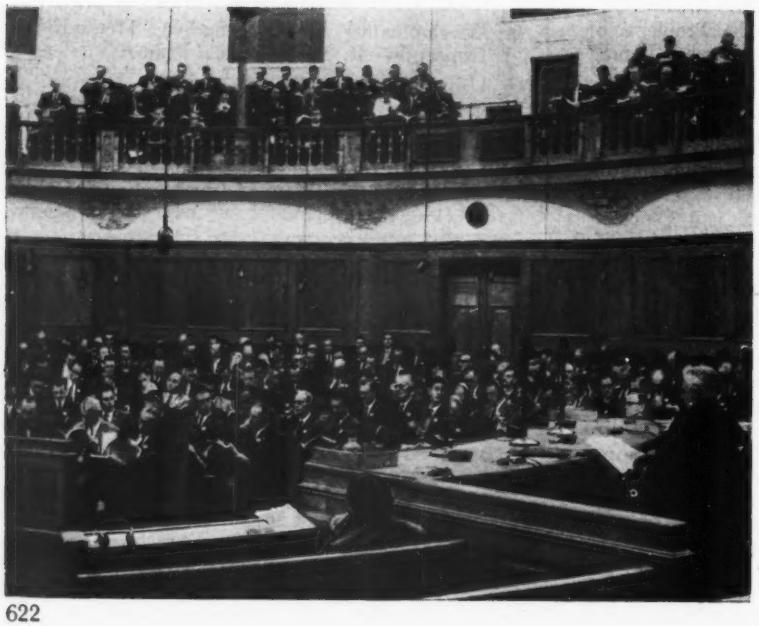
Unfortunately for many, the E.O.Q.C. Conference quickly became over-subscribed, but for those who were unable to attend an edited version of the proceedings will be reported in the E.O.Q.C. Bulletin. Copies of the Papers which were presented are available from the British Productivity Council, 21 Tothill Street, London, S.W.1, at a price of £2 10s. 0d. for members of the E.O.Q.C. Subscribers Service and £3 0s. 0d. for non-members. The Papers which were presented are as follows:-

1. The Value of the Control of Product Quality—Mr. F. Nixon, U.K.
2. The Establishment of a Realistic Quality Level—Dr. W. Masing, Germany.
3. Achievement of the Established Quality Level—Professor Paul Clifford, U.S.A.
4. Developments in Qualitative Methods of Inspection—M. E. Befahy, Belgium.
5. Developments in Quantitative Methods of Inspection—R. M. Ramback, France.
6. Using Frequency Distribution for Diagnosis—Professor A. Palazzi, Italy.
7. Short Cuts to Diagnosis — Dr. Ellis R. Ott, U.S.A.
8. The Economy of Planned Investigations—Dr. D. R. Cox, U.K.
9. Developments in Evolutionary Operation—Dr. G. E. P. Box, U.S.A./U.K.
10. The Role of Quality Assurance in Product Quality—Capt. B. L. Lubelsky, U.S.A.
11. The Concept of Integrated Control Quality—Mr. J. van Ettinger, Holland.

The photographs overleaf were taken during the Presidential reception at the Institution Headquarters and at the Conference in session.

E.O.Q.C. Conference

At the President's reception held at the Institution's Headquarters on 2nd September: (top left) Mr. G. Ronald Pryor receives Dr. W. Masing, Immediate Past President of the European Organisation for Quality Control, and Mrs. Masing; (top right) Sir Charles Norris, Chairman, British Productivity Council, and Lady Norris, chat with the President; (left) Mr. H. W. Bowen, O.B.E., Immediate Past Chairman of Council, and Mrs. Bowen, are greeted by the President.



Mr. G. Ronald Pryor presiding over the Opening Session of the E.O.Q.C. Conference at Church House, Westminster.

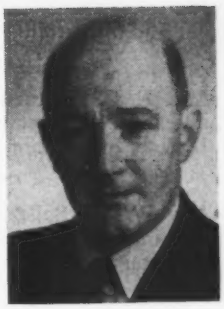
NEWS OF MEMBERS

OUTSTANDING SERVICE TO THE INSTITUTION

Two of the Institution's most prominent members, **Mr. J. France** (left) and **Mr. E. Percy Edwards** (right) recently retired from the Education Committee after setting up a record of service which is—so far—without parallel. Between them they have served continuously on the Committee for over 50 years—Mr. Edwards for 30 years and Mr. France for 27 years. Both are Past Chairmen of the Committee.

The Council's warm appreciation of this remarkable achievement, from which the Institution has derived inestimable benefit, was recorded at the July meeting.

Both members continue to serve on the Council, and Mr. Edwards also serves on the Membership Committee.



PRINCIPAL OFFICERS ON PERA COUNCIL

At the recent Annual General Meeting of the Production Engineering Research Association, the President of the Institution, **Mr. G. Ronald Pryor,** and the Vice-Chairman of Council, **Mr. A. L. Stuchbery,** were re-elected Vice-Chairmen of PERA Council.

The Institution's Chairman of Council, **Mr. R. H. S. Turner,** was also elected to PERA Council.

RETIREMENT OF MR. C. D. ALDER

Mr. C. D. Alder, O.B.E., Member, who recently retired as Principal of Cornwall Technical College, Pool, leaves behind him, in the form of the imposing new college buildings at Trevenson, a permanent memorial to his 30 years of selfless devotion to the development of technical education in his native county.

Mr. Alder, who was Chairman of the Cornwall Section of the Institution from 1942 - 1944, was born in Bodmin, and on leaving school served an apprenticeship in Devonport Dockyard. Following service in France in the First World War, he studied engineering at Birmingham University where he took an Honours Degree. He was awarded the Bowen Scholarship, tenable at the University, but accepted an appointment as Head of the Electrical Department at the Gamble Technical Institute, St. Helens.

In 1930 he returned to Camborne as Principal of a small technical school, when technical education in Cornwall was almost non-existent. The impressive developments since that time are due in no small degree to Mr. Alder's vision, ability and perseverance. He has been a member of the Regional Council for Further Education since 1947, and serves on many of its sub-committees and on its academic board. He is also a member of the National Advisory Council on Education for Industry and Commerce; various joint industrial councils, particularly those relating to the motor and building trades; and the National Advisory Council's advisory sub-committee on further modern education for agriculture.

Mr. Alder's many friends throughout the Institution will wish for him a long and happy retirement.

Mr. L. L. Allen, Member, has now relinquished his position as Head of Engineering Department at the Hendon Technical College, and has taken up an appointment as Principal of Willesden Technical College.

Mr. W. H. Mather, O.B.E., Member, was appointed Managing Director of The Head Wrightson Machine Co. Ltd. on 1st June last.

Mr. J. C. Sharman, O.B.E., Member, has been appointed a Director of Garringtons Ltd., and a Director of Precision Forgings Ltd.

Mr. W. R. Bailey, Associate Member, has been appointed Chief Production Engineer of The Weaver Manufacturing & Engineering Co. Ltd., Bedford.

Sqd.-Ldr. C. B. Bolton, Associate Member, has been posted from R.A.E., Farnborough, where he was employed in the Mechanical Engineering Department, and is now Officer Commanding Provost Servicing and Ground Engineering Squadron at Linton-on-Ouse.

Mr. R. P. Bull, Associate Member, has recently been promoted to the position of Chief Production Engineer with A. A. Jones & Shipman Ltd., Leicester.

Mr. C. J. Callaghan, Associate Member, has relinquished his appointment as a Lecturer in Production Engineering and Management at Enfield Technical College and has taken up a similar appointment for the New Zealand Government at Wellington Technical Correspondence School.

Mr. D. R. Coburn, Associate Member, has recently joined Mallory Batteries Ltd. as Chief Draughtsman, having left a similar position with Cathodean Electronic Ltd.

Mr. H. Deacon, Associate Member, has relinquished his position as Education Officer to Handley Page Ltd., and has taken up an appointment as Senior Lecturer at Hatfield Technical College.

Mr. H. B. Marson, Associate Member, has recently joined the Court Works Ltd., Madeley, Shropshire, as Production Engineer, responsible to the Managing Directors.

Mr. D. R. Parker, Associate Member, has been appointed Works Manager to Clarkson (Engineers) Ltd., Nuneaton.

Mr. H. W. Reece, Associate Member, is now a Lecturer in the Production Engineering Department of the Lanchester College of Technology.

Mr. A. Rigshaw, Associated Member, has relinquished his post as Planning Engineer with Messrs. Kearney & Trecker — C.V.A. Ltd., Hove, and has taken up an appointment as Assistant Grade B at Southall Technical College.

Mr. W. M. Stern, Associate Member, has relinquished his position as Assistant Works Manager with Messrs. Hayward Tyler, Luton, and has taken up an appointment as Production Manager of Powell Duffryn Carbon Products Ltd., Hayes, Middlesex.

Mr. L. Walker, Associate Member, has recently been appointed to the Board of T. Rowbotham & Co. Ltd., Stockport, where for a number of years he has been Works Manager.

Mr. R. B. Wilkinson, Associate Member, is now Chief Buyer at Bristol Siddeley Engines Ltd., at their Bristol factories.

Mr. J. E. Adlington, Graduate, has relinquished his position with I.C.I. Ltd., Billingham Division, County Durham, and has taken up an appointment as a Mechanical Engineer with the Ministry of Works, Northern Nigeria.

Mr. M. J. Berry, Graduate, has recently relinquished his appointment as Chief Test Equipment Engineer of the De Havilland Aircraft Company, Christchurch, to take up an appointment as Departmental Manager with Batchelor Foods Ltd., Ashford, Kent.

Mr. D. Brown, Graduate, has recently left English Electric Co., Netherton, where he was employed as a New Development and Process Engineer, and has taken up a position with the U.K.A.E.A., Production Group, Capenhurst Works as an Engineer III (Planning).

Mr. M. R. L. Daniel, Graduate, has relinquished his position with J. Lucas Ltd., and has taken up an appointment as an Assistant Development Engineer with C.A.V. Ltd.

Mr. P. J. Galliford, Graduate, has been appointed Chief Engineer to Messrs. Eatoughs Ltd.

Mr. R. Griffiths, Graduate, has relinquished his appointment as Chief Draughtsman with Universal Metal Products Ltd., and will be taking up a position of Works Engineer with Plastic Engineers Ltd., Treforest.

Mr. J. Harrison, Graduate has recently taken up an appointment as Head of Engineering Department at the Dacorum College of Further Education, Hemel Hempstead.

Mr. R. Hordern, Graduate, has relinquished his position as a Section Leader on Machine Tool Development with Messrs. Waddington Tools Ltd., and is now self-employed as a Design Consultant.

Mr. J. F. Percival, Graduate, has recently left the United Kingdom to work in Italy for two years for his Company, Production Engineering Ltd., in association with Alfa Romeo SPA, of Milan.

Mr. K. Seshadri, Graduate, has relinquished his position of Senior Jig and Tool Designer at Lockheed Hydraulic Brake Co. Ltd., and has now joined the University of Khartoum in their Faculty of Engineering.

Mr. W. Turnbull, Graduate, has relinquished his position with Messrs. McKechnie Brothers Ltd., Aldridge, and has taken up an appointment as Plant Engineer at the Leeds Factory of the Yorkshire Imperial Metals Ltd.

CORRECTION

Mr. R. E. Mills, Member, was incorrectly described in the September issue as "Immediate Past Chairman of the Research and Technical Committee." He is, of course, Immediate Past Chairman of the Standards Committee.

DIARY FOR 1960-1961

OCTOBER 12 - 14 ... **National Conference,** at The Dome & Corn Exchange, Brighton.
Theme : **"Modern Trends in the Manipulation of Metals."**

NOVEMBER 2 ... ... **Annual Dinner,** at the Dorchester Hotel, London.

NOVEMBER 10 ... ... **The 1960 Sir Alfred Herbert Paper,** at The Royal Institution, London.
Speaker : **Professor R. E. Lane,** Nuffield Department of Occupational Health, University of Manchester.
Subject : **"Health Services in Industry."**

1961
JANUARY 12 ... ... **The 1960 Lord Sempill Paper**
Speaker : **Sir Percy Hunting,** F.C.I.S.
Subject : **"The World's Future Transport Requirements."**

MAY 24 ... ... **The 1961 Viscount Nuffield Paper,** at The University of Bristol.
Speaker : **Sir Willis Jackson,** F.R.S., Director of Research and Education, A.E.I. (Manchester) Ltd.

ASSOCIATE MEMBERSHIP EXAMINATION, 1960

UNITED KINGDOM

PASS LIST — PART I

Biswas, Bimal K.
Clark, David H.
Morris, Roy
Perera, K. R.
Shum, Lanson Y. S.
Sida, Norman W.

PASS LIST — PART II

Abbott, Douglas H.
Archer, Thomas H.
Ball, Gerald F.
Baxter, David J.
Beckett, David E.
Bishop, Edwin
Bridger, Rex R.
Browne, Peter J.
Burton, James A.
Chadwick, Leonard
Chakrabarty, Nityananda
Chakravarty, Sujit
Clark, David H.
Clarke, Brian C.
Clements, James E.
Cochrane, Graham J.
Cotterill, David W.
Cross, Alan
Culling, Derrick H.
Davis, Eric G.
Davison, John O.
Eccles, Albert L.
Forster, Francis R.
Frith, Geoffrey
George, Raymond J.
Greenwold, Geoffrey E.
Heffer, Maurice R.
Hooper, Arthur E.
Hope, Alan
Howells, Francis J.
Hudman, John
Idell, John A.
Langfield, Ronald W.
Lapthorn, Edwin H.
Lee, Frank L.
Lee-Rand, James K.
Lewis, William E. J.
McDowell, George W.
McNeilly, Robert J.
Morris, Roy
North, Charles L.
Palphreyman, Wilfred
Perera, K. R.
Raymond, John
Richardson, Leonard
Roberts, George H.
Roberts, William H.
Robinson, Leonard A.
Shaw, David V.
Shum, Lanson Y. S.
Sida, Norman W.
Skipp, Geoffrey B.
Smith, Eric J. T.
Steel, Barrie D.
Turner, Charles P.
Twineham, Leonard
Vaseer, Teja S.
Warburton, Arthur
Ward, John H.
Whittles, Derek E.
Wilson, Brian J.
Wilson, Gordon T.
Wilson, Peter J.
Wood, John M.
Wylie, John C.

PASS LIST — PART III

Anderson, John R.*
Avill, Fred
Aziz, Ahmad
Barbasio, Anthony J.
Barber, John M.
Batty, Robert
Beedie, Peter D.
Bhattacharyya, Abhas
Birtwistle, Alexander
Black, Peter
Bland, Joseph L.*
Blowers, David H.
Bridger, Rex R.
Burton, James A.
Butcher, Ian
Cantrell, Jack
Chappell, Colin W.*
Clark, Colin J.*
Clark, Derrick M.
Clarke, Ronald H.
Cross, Alan
Culling, Derrick H.
Davies, John H.
Davison, John O.
Edwards, Kenneth C.*
Etherington, Clifford
Eyre, Brian
Ferguson, Bob
Flack, John H.*
Fox, Frederick T.*
Frith, Geoffrey
Fussell, Raymond S.*
Garton, John E.
Green, Cyril A.*
Hargreaves, Frank E.*
Hayes, John P.*
Heap, Alan P.
Hinde, Henry P.
Hooper, Arthur E.*
Howes, Raymond F.
Hulberts, Mark R.
Idell, John A.
Iredale, Ronald
Jowitt, Peter F.*
Kenton, Philip J.
Kite, Sidney H.
Langfield, Ronald W.
Lapthorn, Edwin H.
Leah, Charles
Little, Joseph
Lloyd, Derek J.*
Mainprize, Peter H.
McDowell, George W.
McGee, Raymond R.*
Miller, Alan
Newman, Albert E.
Newsham, Ronald
Nickless, Thomas M.
Noblett, Frank
Popperwell, Robert F.*
Rees, Eric D.
Richardson, Leonard
Roberts, William H.
Rossiter, Lionel C.
Selwood, Victor H. G.
Scothern, Gerald L.*
Scott, John E.
Sherwood, Kenneth F.
Shum, Lanson Y. S.
Simpson, K. W.*
Spells, Gerald M.*
Steel, Barrie D.
Toner, Ernest
Warner, Leslie J.
Weatherhogg, John J.
Wilcock, Eric
Wilson, Peter J.*
Williams, Alwyn *

** NOTE — These candidates as a special concession were allowed to take Process Study and Work Study in lieu of the Part III requirement.*

OVERSEAS CANDIDATES

PASS LIST — PART I

Ballal, H. Karunakar
Bensoussan, Meir
Chan, Kit M.
Chwang, Tien F.
Dobinson, George
Kwong, Keng C.
Raja, P. S. Chandra Sekara

PASS LIST — PART II

Anderson, Mervyn I.
Beard, Dick
Brown, Harold J.
Chopra, Amarjeet S.
Kay, Robert B.
Khokar, Kartar S.
Kruger, Petrus G.
Landrock, Lawrence G.
Weinryb, Ykutiel
Wiseman, Trevor L.

PASS LIST — PART III

Brown, Harold J.
Chopra, Amarjeet S.
Gill, Frederick H.
Grindrod, Bernard
Jacobs, Willem Ch.
Landrock, Lawrence G.
Patwardhan, Vijay Y.
Sheikh, Mohammad A.
Viswanathan, Chittus S.
Warsi, Syed A.

NEW BRITISH STANDARDS

Copies of the following British Standards, recently issued, may be obtained from the British Standards Institute, 2 Park Street, London, W.1, at the prices stated.

B.S. 1728 : —— Methods for the analysis of aluminium and aluminium alloys. B.S. 1728 Part 11 : 1960 **Method for the determination of silicon (perchloric acid method). 3s. 0d.**

B.S. 3117 : —— Wheel pairs for locomotives and rolling stock (dimensions). B.S. 3117 Part 2 : 1960 **Wheel centres and monobloc wheels. 4s. 6d.**

B.S. 3238 : —— Graphical symbols for components of servo-mechanisms. B.S. 3238 : Part 1 : 1960 **Transductors and magnetic amplifiers. 4s. 6d.**

B.S. 3243 : 1960 **Hand-operated chain pulley blocks. 5s. 0d.**

B.S. 3247 : —— Salt for spreading on highways for winter maintenance. B.S. Part 1 : 1960 **Rock salt. 3s. 0d.**

B.S. 1121 : —— Methods for the analysis of iron and steel. B.S. 1121 Part 41 : 1960 **Lead in carbon and low alloy steel. 3s. 0d.**

B.S. 2911 : —— Letter plates. B.S. 2911 Part 2 : 1960 **Standard height and fixing recommendations. 3s. 0d.**

B.S. 3245 : 1960 **Jointing compounds for use in liquefied petroleum gas appliances and installations. 4s. 0d.**

B.S. 3246 : 1960 **Halsted's mosquito forceps. 4s. 0d.**

B.S. 3249 : 1960 **Cables and flexible cords insulated with varnished cambric and heat-resisting fibre. 5s. 0d.**

B.S. 173 : 1960 **Rotating electrical machines for use on road and rail vehicles. 10s. 0d.**

B.S. 576 : 1950 **Acetic acid (with published amendments).**

B.S. 662 : 1950 **Carbon disulphide (with published amendment).**

B.S. 1594 : 1950 **Diacetin (glyceryl triacetate) (with published amendment).**

B.S. 1834 : 1952 ***iso*Propyl acetate.**

B.S. 1835 : 1952 **2-Ethylhexyl alcohol (2-ethlhexanol) (with published amendment).**

B.S. 1933 : 1953 **Varnish-bonded glass-covered copper conductors. B.S. 1933 Part 1 : Round wire (with published amendments).**

B.S. 1940 : 1953 **Ethyl methyl ketone (methyl ethyl ketone).**

B.S. 1941 : 1953 ***iso*Butyl methyl ketone (methyl *iso*butyl**

B.S. 1993 : 1953 **secButyl alcohol (with published amendment).**

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

Aitchison, Leslie. **"A History of Metals."** 2 vols. *London, Macdonald and Evans,* 1960. 647 *pages. Photographs. Illustrated. Maps. Diagrams. Tables.* £8 8s. 0d.
Professor Aitchison is well-known for his works on metallurgical subjects. The present work naturally has a metallurgical bias, but should interest others besides metallurgists: historians, archaeologists, engineers, artists and craftsmen. In it the author traces the history of metals, of their discovery, and of how and for what they have been used, from late stone age times to the present day. There are numerous photographs and other pictures, tables and diagrams.

The first volume traces the emergence of the first seven metals men knew. It begins with the primitive use of gold and native copper, proceeding then to examine the discovery of copper smelting at about 4,000 B.C. Thereafter lead, silver, tin, iron and mercury were successively found and were used along with gold and copper in appropriate ways. After a period dominated by copper, bronze was developed and played a principal role; later iron was discovered and for many purposes ousted both copper and bronze. A way of carburising iron, to make a kind of steel, was also invented and this alloy, along with brass, soft solders and pewter, completes the list of metallic materials used until the end of the first millenium A.D. For 4,000 years men had speculated on the nature of metals and had formed remarkable opinions on the relations between the several elements and the possibility of changing one metal to another. The history of these ideas has been carried so far as the 17th century, but that of practical metal-winning and metalworking has been taken only to A.D. 1,000.

In volume 2 it is shown that the employment of mechanical power eventually introduced great changes and improvements into the ways of producing the old metals and alloys. The complete revolution in the modes of philosophical and scientific thinking, occurring at the end of the Middle Ages, opened the way to the discovery of new processes for extracting metals from their ores and for converting them into articles for men's use. Explorers found new continents, and the knowledge possessed by Europeans about metals and on metal-winning techniques was transmitted to the ends of the earth Scientific and technical advances multiplied by many times the quantities of metal won from ores and minerals, and the number of alloys that could be made; they even led to the creation of metals not found in nature.

American Society of Tool Engineers, Detroit, Michigan. **"Collected Papers 1959."** *Detroit, the Society,* 1959. 50 Papers in two binders. *Illustrated. Diagrams.* £10.
Contents of Volume 1. Bergstrom. The history of metal cutting — McCann. Design problems with precision elephant type machine tools — Bingham. Current developments in numerically controlled die sinking machines — Thuma. Machine selection and application in a large industrial plant — Eary. Tooling experiments using statistics — Chyle. Welding of tool steels — Dutt and Treat. Simplified and more accurate model reproduction with RTV silicone rubber — Frommelt. A new approach to machinability dimensions — Bendixen. Power measurements in milling—Dexter. Zero point one (Quality control)—Taylor. Control of overhead costs—Beach. Capital costs and you — Long. Control of research and development costs — Purdy. Key factors in material cost control — Witsche. Cost control in quantity production — Kaiser. Control of labour costs — Studer. Cost control through design — Bayer. The industrial engineer's responsibility for design cost control — Wood. For better understanding of your business by your people — Vincent. Designs for successful living — Ferguson. The tool engineer and the tools of yesterday — Taylor and Jordon. Developing creativity in engineering — Seminara and Peters. Human factors responsibilities of design engineers — Smith. The potential machine designer.
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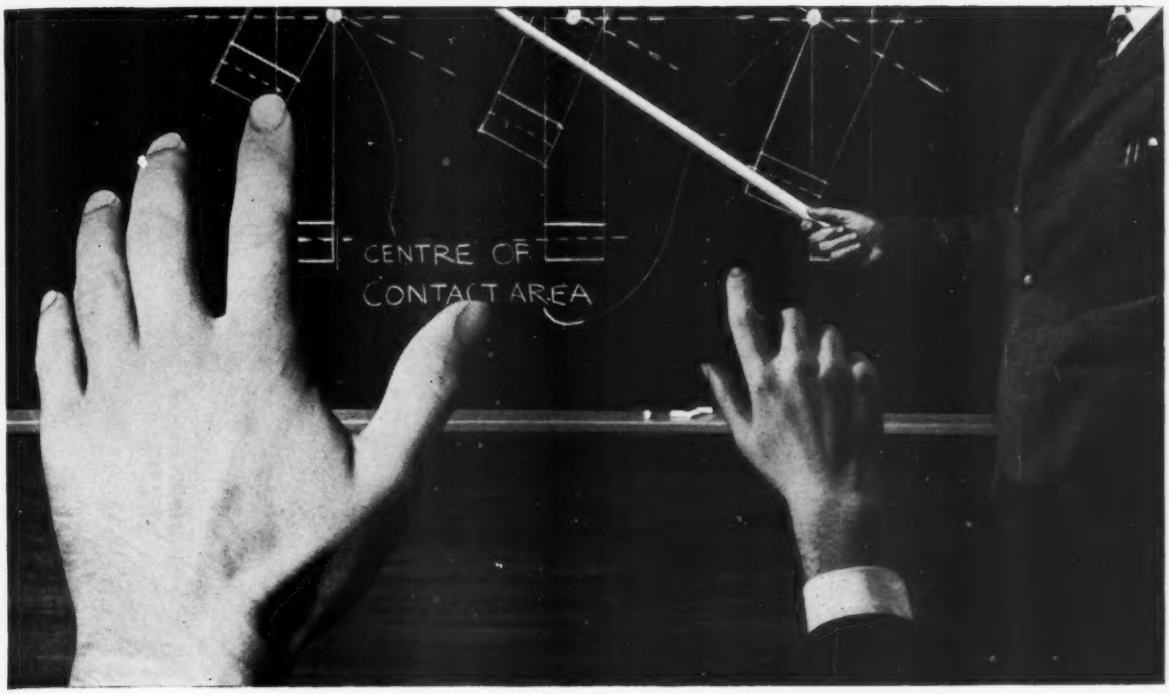
American Standards Association, New York. **"Standardisation: What's in it for me? Proceedings of the Ninth National Conference on Standards."** *New York,* 1958. 128 *pages. Illustrated. Diagrams.* 45s. 0d.
50 short Papers under the following headings: Standards of living and standards for trade — Standard methods and specifications: Foundations for standardisation in industrial operations — Significance of international standardisation to U.S. industry — Here's how standards make money for my company — Industry's responsibility in the nuclear standards field — How standards and machine tool progress — Producer/consumer benefits of textile standardisation — Safety labelling standards for hazardous substances — Producer/consumer benefits from electronic standardisation — What photographic standards mean to the consumer.



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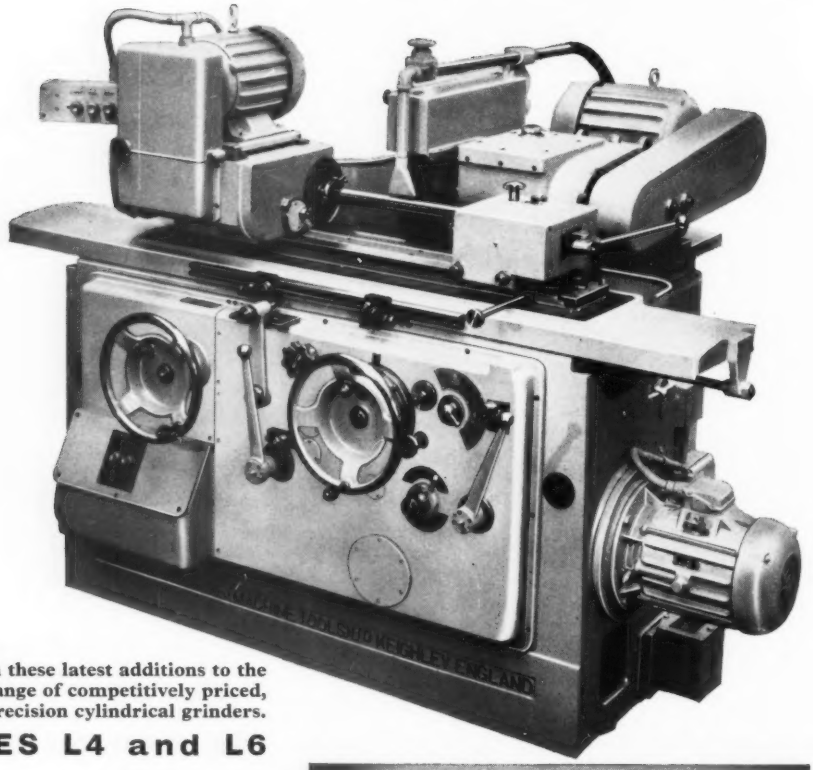

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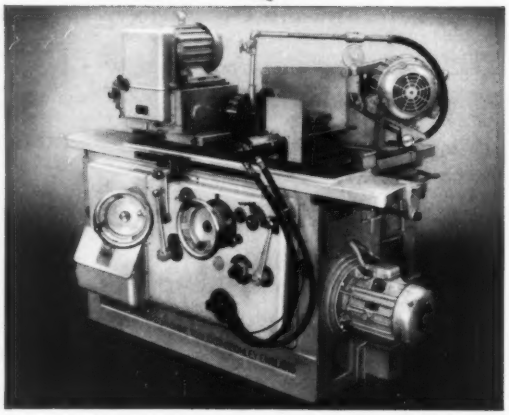

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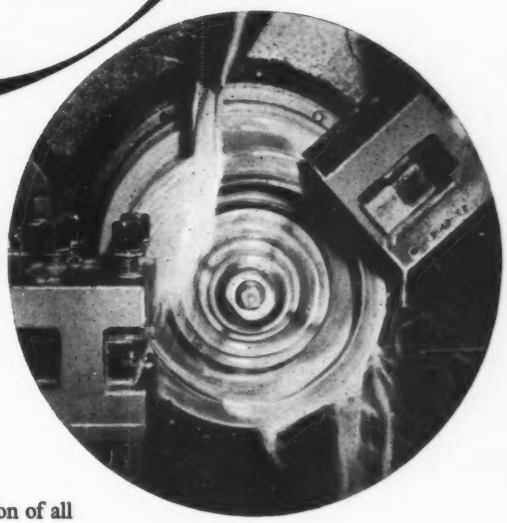

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- Single or double automatic operation cycle.
- Plunge cut or traverse grinding.
- Feed accelerator reduces production time.
- Diminishing feed rate to zero with variable dwell.
- Adjustable oscillation.

Full details of these and other outstanding advantages sent on request.

Precision plus Production

THE CHURCHILL MACHINE TOOL CO. LTD.,

BROADHEATH, NR. MANCHESTER . Phone Altrincham 3262

Export Sales Organisation: Associated British Machine Tool Makers Ltd., London, Branches and Agents.

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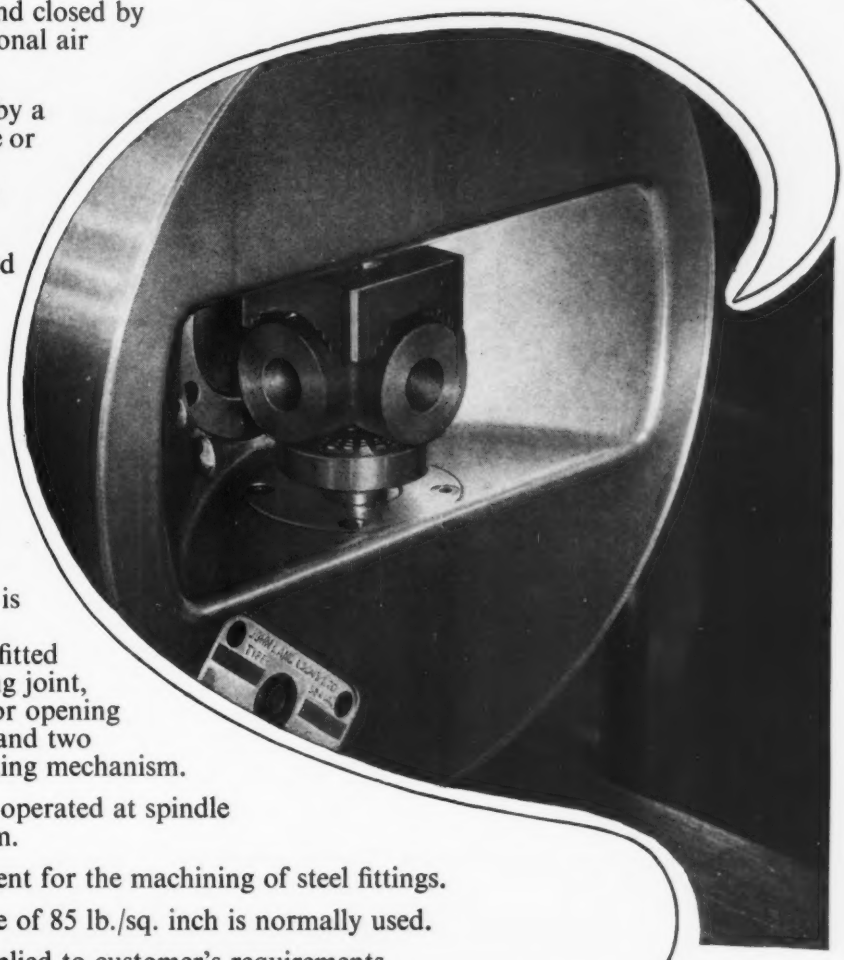
C675-ID

POWER INDEXING

WITHOUT STOPPING THE MACHINE SPINDLE

CHUCKS CAN BE FITTED TO EXISTING MACHINES

LANG POWER CHUCKS



- The chuck is opened and closed by power as in a conventional air chuck.
- Indexing is controlled by a hand valve, a foot valve or a push-button valve operated automatically by the turret slide.
- The workpiece is indexed progressively in 90° steps.
- Indexing time is less than one second.
- Accuracy of index is within ·015″ at a 12″ radius.
- The lock is sufficient for all normal duties.
- The air cylinder which is carried on the back of the machine spindle is fitted with a four-way running joint, two leads being used for opening and closing the chuck and two for operating the indexing mechanism.
- The equipment can be operated at spindle speeds up to 1500 r.p.m.
- Gripping power sufficient for the machining of steel fittings.
- Works air line pressure of 85 lb./sq. inch is normally used.
- Valve gear will be supplied to customer's requirements.

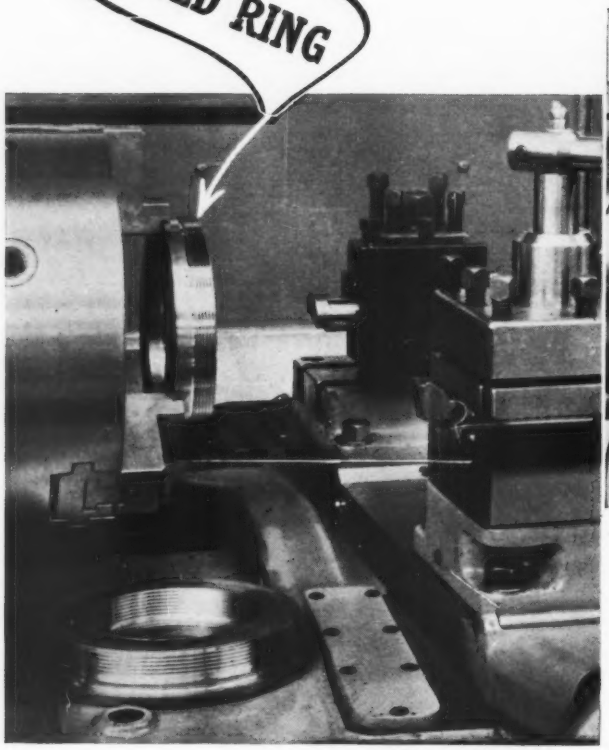
LONDON OFFICE
ASSOCIATED BRITISH MACHINE TOOL MAKERS LIMITED
17 GROSVENOR GARDENS SW1

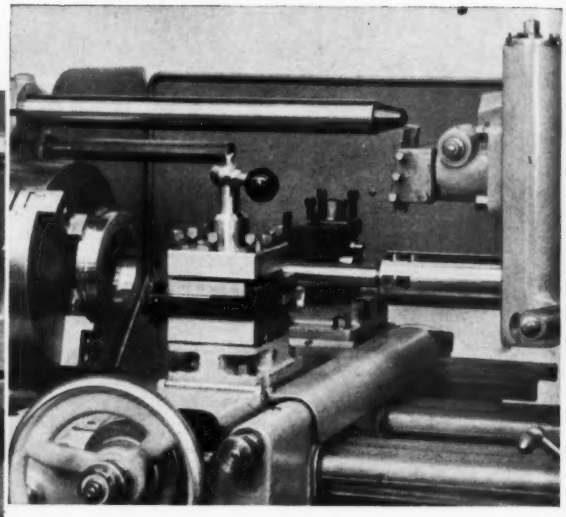
JOHN LANG & SONS LTD.
JOHNSTONE RENFREWSHIRE SCOTLAND
Telephone: Johnstone 400 Telegrams: "Lang Johnstone"

BRITISH MACHINE TOOL MAKERS ASSOC. ABMTM LTD

L221-E1

Maximum Production Special Tool Layouts





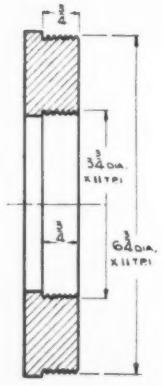
Ward

No. 7 TURRET LATHE

FITTED WITH 12in TUDOR 3-JAW CHUCK

STEEL FORGING

40 Ton Tensile Steel
En.8.



All Tungsten Carbide Cutting Tools

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Grip Forging in Three-Jaw Chuck	—	—			
2. Turn Outside Diameter	—	Front 1	416	765	266
3. Undercut and Face Flange and Chamfer o/dia.	—	—			
	—	Front 2	416	765	Hand
4. Screwcut o/dia. × 11 T.P.I. (7 cuts)	—	Front 3	280	495	11 T.P.I
5. Face End	—	Front 1	675	1193	52
6. Bore, Undercut and Chamfer	1	—	416	408	134
7. Screwcut Internal Thread 11 T.P.I. (7-cuts)	—	—			
	—	Rear	416	408	11 T.P.I.
8. Remove Part from Chuck	—	—			

Total Floor-to-Floor Time for above operations: 5 minutes.

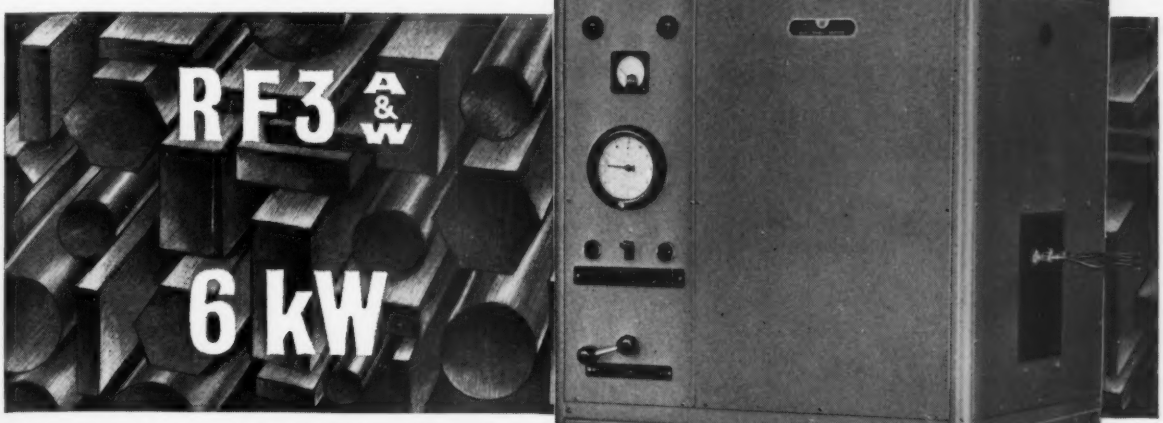
NOTE:— Time for cutting external thread 11 T.P.I. (7 cuts) 40 seconds
Time for cutting internal thread 11 T.P.I. (7 cuts) 36 seconds

H·W·WARD & CO LTD
SELLY OAK
BIRMINGHAM 29
TELEPHONE SELLY OAK 1131

BRITISH MACHINE TOOL MAKERS ASSOC. ABMTM LTD

WC54

Another addition to the PYE Range of Induction Heaters



INDUCTION HEATING UNITS

These 6 kW induction heaters have been designed for continuous operation and incorporate the latest design techniques. The generators are of medium impedance output being suitable for general purpose heating applications such as annealing, brazing, hard and soft soldering, hardening and tempering. The availability of a high work coil kVA in association with multi-turn coils permit the heating of a wide range of ferrous and non-ferrous loads.

The oscillator value may be either air cooled (Type R.F. 3/A) or water cooled (Type R.F. 3/W) depending upon customer requirements. With the R.F. 3/A water is used only for cooling the tank and work coils. In the case of the R.F. 3/W a common water supply is employed for cooling the oscillator valve, tank and work coils.

Due to the simplicity of operation unskilled labour may be employed enabling production costs to be reduced. The controls, indicator lamps, anode current meter and process timer are conveniently grouped on the front panel. Compact design allows the equipments to occupy the minimum of floor space. The equipments in operation are extremely dependable as a result of advanced design and the use of components of proved reliability.

PYE PROCESS HEATING

FREE TECHNICAL ADVICE *is offered on the applications of R.F. heating to Tempering, Brazing and Hardening processes etc. Our technical representatives are at your service, or we will send you full details—please tick the appropriate box in the coupon.*

PYE LTD. PROCESS HEATING DIVISION
Telephone: CAMBRIDGE 57590

To Pye Ltd. Process Heating Division, 28 James Street, Cambridge
Please send me details of Pye Process Heating Equipment.

NAME .....

COMPANY .....

ADDRESS ..... IPE 10

Please ask your Technical Representative to telephone for an appointment ☐ *Please send me full details* ☐

OPTICAL DIVIDING HEAD

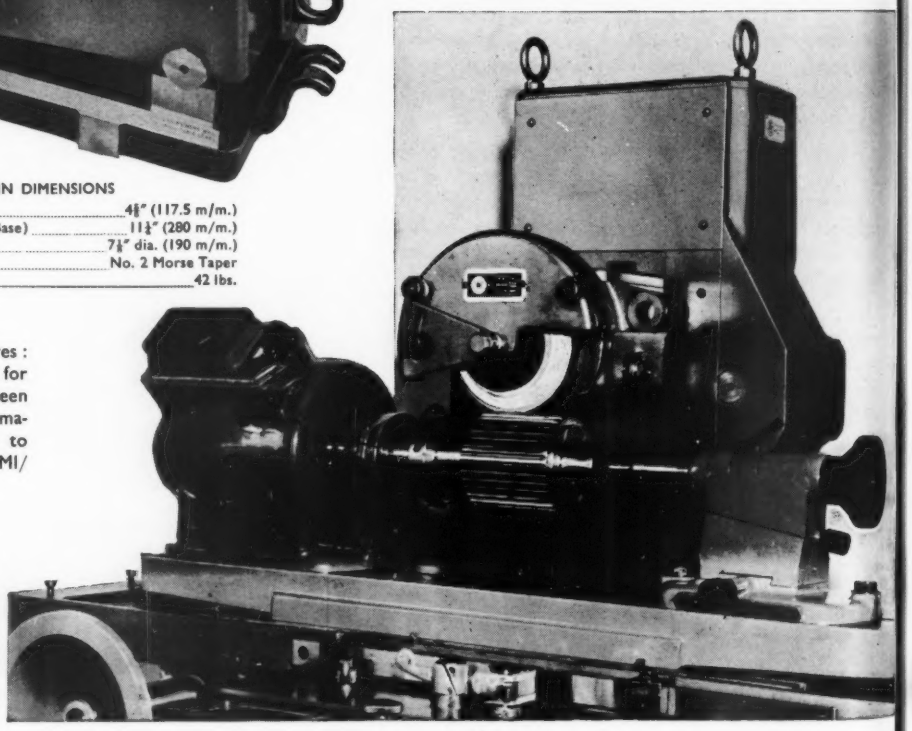
O.D.H. MOUNTED ON SINE TABLE

COMBINING HIGHEST PRECISION WITH ROBUST CONSTRUCTION

MAIN DIMENSIONS

Height of Centres	4⅝" (117.5 m/m.)
Centre Distance (on Base)	11⅛" (280 m/m.)
Size of Face Plates	7½" dia. (190 m/m.)
Size of Centres	No. 2 Morse Taper
WEIGHT OF HEAD	42 lbs.

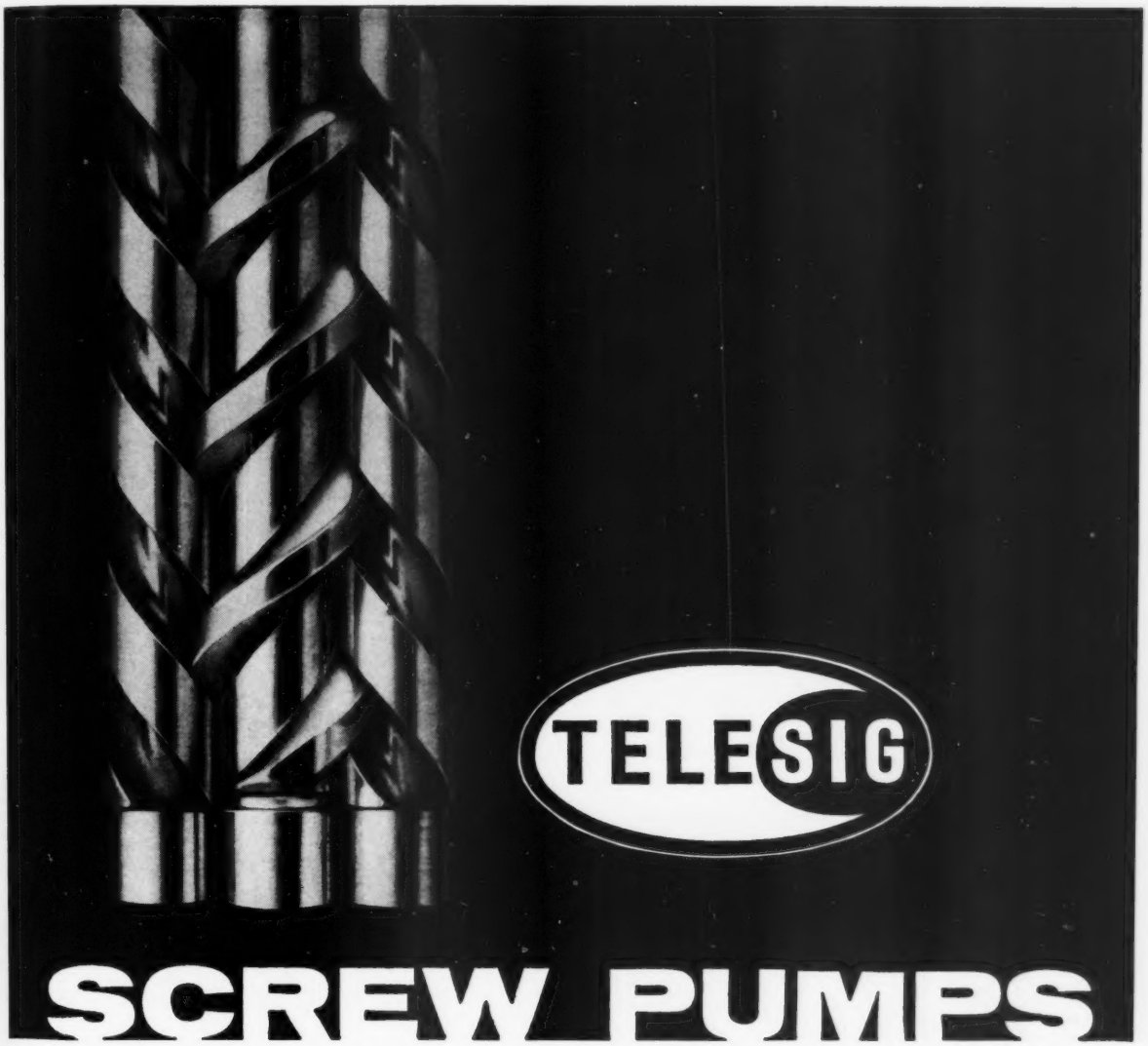
Combining the following features : Dead centre, adjustable drive for zero settings, large vernier screen reading direct to 6 secs. (estimation 3 secs.) and conforms to N.P.L. Specification MOY/SCMI/56. Patent 599708.



O.D.H. mounted on JONES & SHIPMAN 540 Grinding Machine, controlling serrations held to a tolerance of 0·0002" both for spacing and diameter

PRECISION GRINDING LTD
MILL GREEN ROAD · MITCHAM · SURREY Phone: MITCHAM 3014

NRP 1632



TELESIG Screw Pumps are positive displacement pumps. Simply constructed, they offer exceptional performance and long life. TELESIG pumps effect delivery by means of three parallel screws engaging each other, the power-driven central screw driving the two side screws. They may be run at high speed thereby reducing motor sizes and installation costs.

TELESIG Screw Pumps offer the following advantages:

- Self priming.
- Delivery free from pressure pulsation.
- High working speed — small size.
- Near-silent operation.
- Simple construction.
- Minimum maintenance and easy replacement of working parts.
- Long life.

TELESIG Screw Pumps are made in three basic ranges: for low pressures up to 300 psi, for medium pressure up to 1000 psi and for high pressures up to 2,500 psi. 42 sizes are available covering a wide range of capacities.

TELESIG

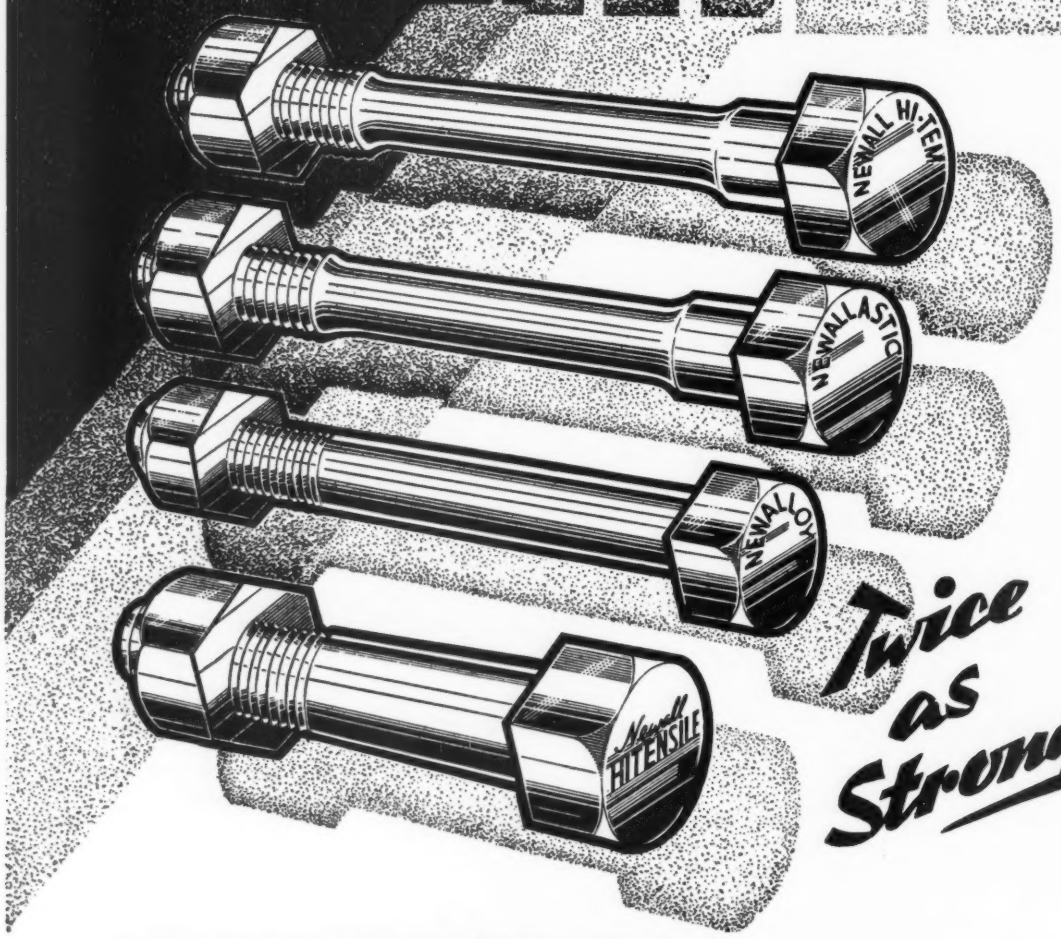
Screw Pumps by Telehoist

TELESIG pumps and equipment are made by Telehoist under licence from the Swiss Industrial Company (SIG).

Telehoist Limited. Cheltenham England. Telephone: Cheltenham 53254

an associate company of Wilmot Breeden Ltd.

NEWALL



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are recognised by engineers as having unique qualities. We shall be happy to supply any engineer designer who is interested with details of the various bolts and studs, which cover the full range of modern requirements.

A.P. NEWALL & CO., LTD. POSSILPARK GLASGOW N2

STRAIGHT BEVEL GEARS

Straight bevel gears are the simplest form of bevel gears, and are widely used for slow-speed drives. They have straight tapered teeth which, if extended, would intersect the gear axis.

SPIRAL BEVEL GEARS

Spiral bevel gears have curved, oblique teeth which are cut or ground to run with localized contact. Their gradual tooth engagement and overlapping tooth action result in smooth, quiet operation, at high loads and speeds.

ZEROL BEVEL GEARS

Zerol bevel gears have curved teeth with zero spiral angle and localized tooth contact. They operate with the same thrust and tooth action as straight bevels, but can be cut or ground on the machines used to produce spiral bevel and hypoid gears.

HYPOID GEARS

Hypoid gears are similar to spiral bevels, except for offset between the pinion and gear axes. They operate even more smoothly than spiral bevels, can be used for higher ratios, and have increased strength of pinion member. Hypoid gears are cut or ground with localized contact on the same machines used for spiral bevel and Zerol gears.

"Gleason" Bevel Gear Machinery

THE COMPLETE GLEASON LINE INCLUDES BEVEL AND HYPOID GEAR AND CURVIC COUPLING EQUIPMENT FOR THE FOLLOWING RANGE OF WORK:

For cutting straight bevel gears

Roughers and Coniflex Generators	up to 35½" diameter
Planers (spur and bevel)	up to 192" diameter
Revacycle Machines	up to 10" diameter

For grinding Straight bevel gears

Generating Grinder	up to 8½" diameter

For cutting spiral bevel, Zerol bevel and hypoid gears

Roughers and Generators	up to 33" diameter
Formate (non-generating) Finishers	up to 22" diameter
Planing-type Generators	up to 91" diameter

For grinding spiral bevel, Zerol bevel and hypoid gears

Generating Grinders	up to 34" diameter
Formate (non-generating) Grinders	up to 24" diameter

For cutting and grinding Curvic couplings and clutches

Curvic Coupling Grinders	up to 60" diameter
Clutch Cutting Machines	up to 9" diameter

For testing and lapping spur and helical gears

Rolling Testers	up to 12" centre distance
Power Testers and Lappers	up to 120" diameter

For testing and lapping bevel and hypoid gears

Power Testers	up to 120" diameter
Rolling Testers	up to 7½" diameter
Lappers (spiral bevel and hypoid)	up to 36" diameter
Concentricity and Spacing Testers	up to 30" diameter
Burnishers . . . automotive spiral bevel and hypoid pinions	

For sharpening Gleason Cutters

Generator Tool Sharpeners
Spiral Cutter Sharpeners
Coniflex Cutter Sharpeners
Revacycle Cutter Sharpeners

For heat treating

Quenching Presses	up to 36" diameter
Rolling Quench Machines	for shafts up to 40" long
Gear surface Hardeners	up to 120" diameter

Deflection and fatigue testing equipment for power drive assemblies

The Gleason Works furnishes cutters, tools, workholding equipment, dies, and complete tooling for all Gleason machines.

GLEASON CUTTER SERVICE

The whole of the engineering service at the Watford premises is devoted to the manufacture and maintenance of all types of Gleason cutters. This up-to-date service is under the direct control of GLEASON WORKS LTD., a new company recently formed in this country to expand the existing cutter service and especially to manufacture other types of cutters previously imported from America.

Write about it to **BUCK & HICKMAN LTD** *Gear Specialists*

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* Increase machine utilisation and output.
* Reduce setting errors.
* Direct readings of workpiece dimensions give greater speed and accuracy.

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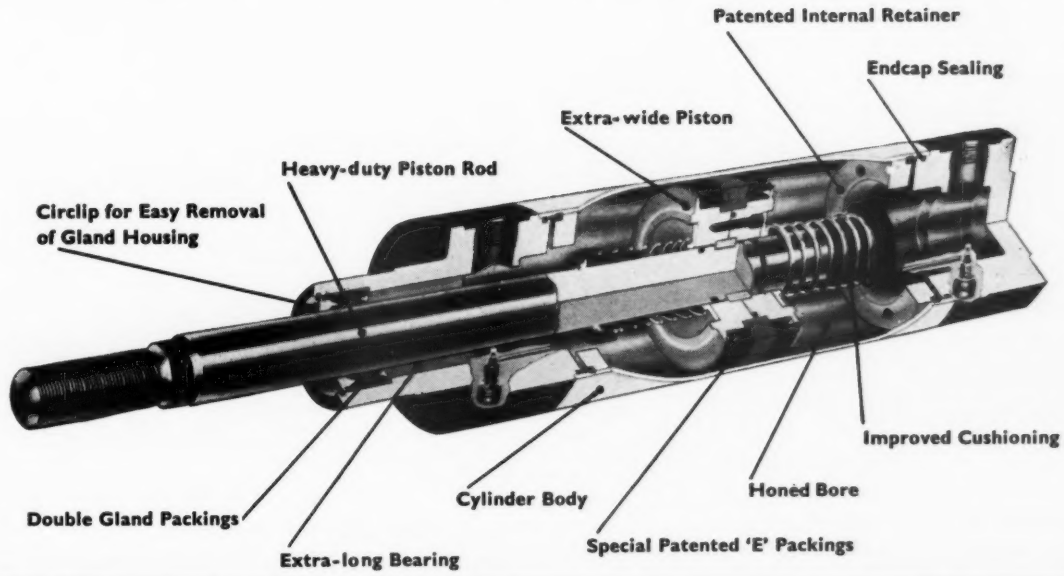
11 detailed REASONS WHY Production Engineers rely on MAXAM PRECISION AND QUALITY



Complete reliability and unrivalled efficiency of operation begin in the Design D.O. Study this part-section of a MAXAM pneumatic/hydraulic cylinder and you will appreciate how attention to minute details of design gives MAXAM products their world-beating quality and proved reliability.

★ **Extra-wide Piston**—for greater bearing surfaces.

★ **Heavy-duty Piston Rod**—manufactured from the finest stainless steel, surface-ground to fine tolerance. Hard chrome-plated rods can be supplied.

★ **Improved Cushioning**—ensures controlled deceleration without impact.

★ **Special Patented 'E' Packings**—having integral retaining rings to provide effective sealing.

★ **Honed Bore**—minimises friction and packing wear. Improved efficiency due to more effective sealing of piston packings.

★ **Cylinder Body**—material strength protects against deformation.

★ **Patented Internal Retainer**—eliminates external methods of securing end-caps. Maximum size of cylinder is o/d of body.

★ **Extra-long Bearing**—in the front end-cap provides substantial support for piston rod.

★ **Double Gland Packings**—provide effective air/oil seal for pneumatic or hydraulic operation.

★ **Circlip for Easy Removal of Gland Housing**—simplifies maintenance.

★ **Endcap Sealing**—for low-pressure hydraulic operation.

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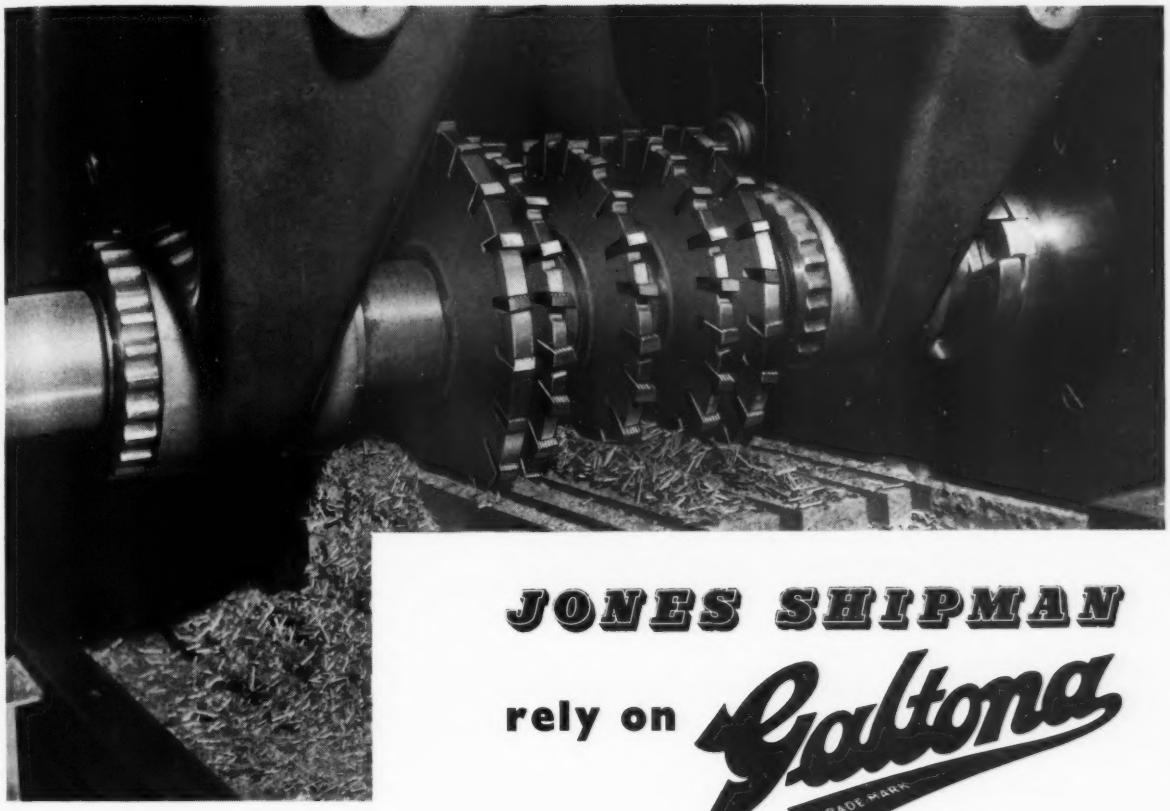
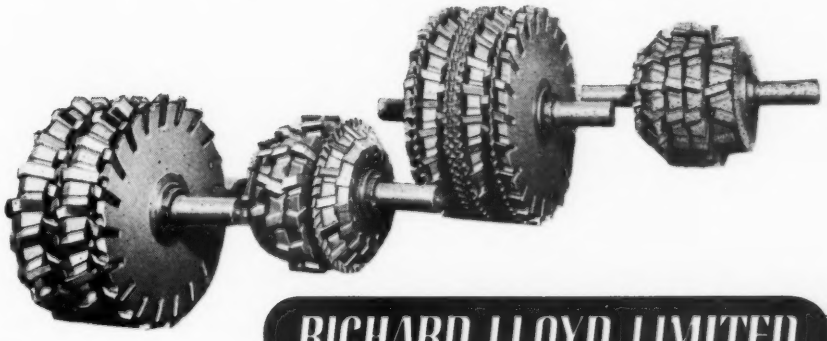


JONES SHIPMAN

rely on Galtona TRADE MARK

SERRATED BLADE CUTTERS

On the production of their well-known Model 540 hydraulic surface grinder, Jones & Shipman Ltd., Leicester, rely on "Galtona" serrated blade cutters for milling the saddle and other components. Our illustrations show one of the operations together with some of the gangs of cutters employed.



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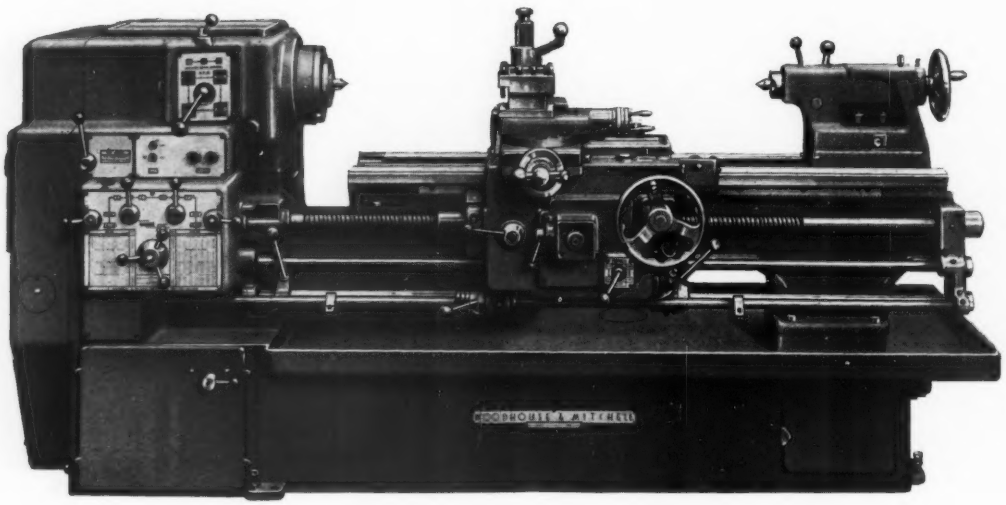
THE wm RANGE

The range of machines produced by Woodhouse & Mitchell includes centre lathes, horizontal boring machines and turret millers. Three of the latest designs are illustrated here: built to modern specifications, they are being used with complete satisfaction by discriminating engineers.

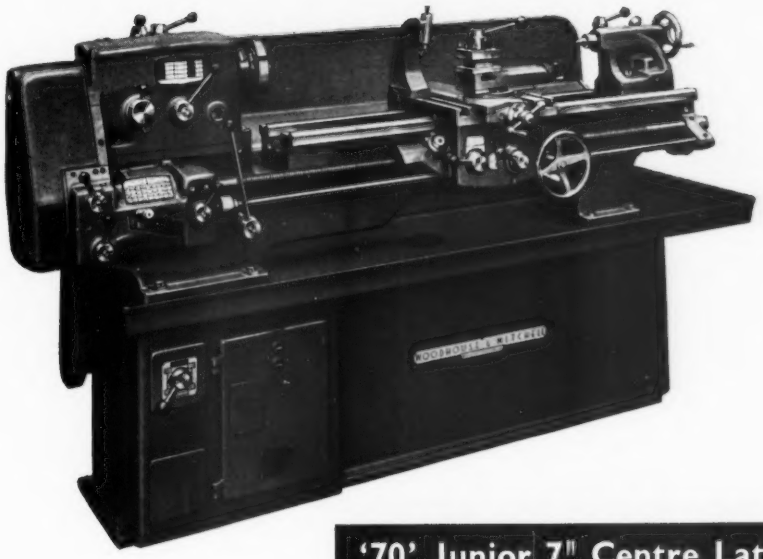
wm wm wm wm



'85' 8½" and 10½" Centre Lathes

8½" size: 10 h.p. motor, 12 speeds
21-945 r.p.m.
10½" size: 12 speeds,
14-630 r.p.m.
alternative, 21-945 r.p.m.

WOODHOUSE & MITCHELL



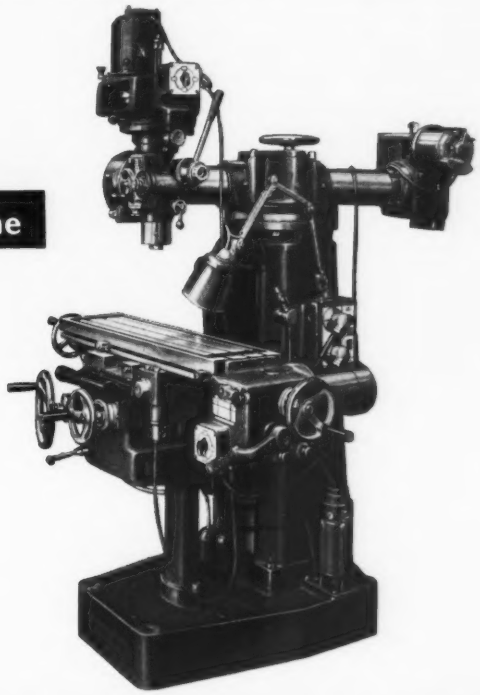
'70' Junior 7" Centre Lathe

2 h.p. motor; 8 speeds, 30-437 r.p.m. also alternatives 44-640 r.p.m., and (when fitted 2-speed motor) 30-874 r.p.m. Sizes are made to admit 45", 54" and 72" between centres.

wm wm wm wm

369 Turret Milling Machine

For milling, boring and jig-boring at any angle, key-way and end milling, die-sinking, mould and pattern-making Table 36" × 9", 10 spindle speeds 100-2,000 r.p.m. (alternative 200-4,000 r.p.m.).



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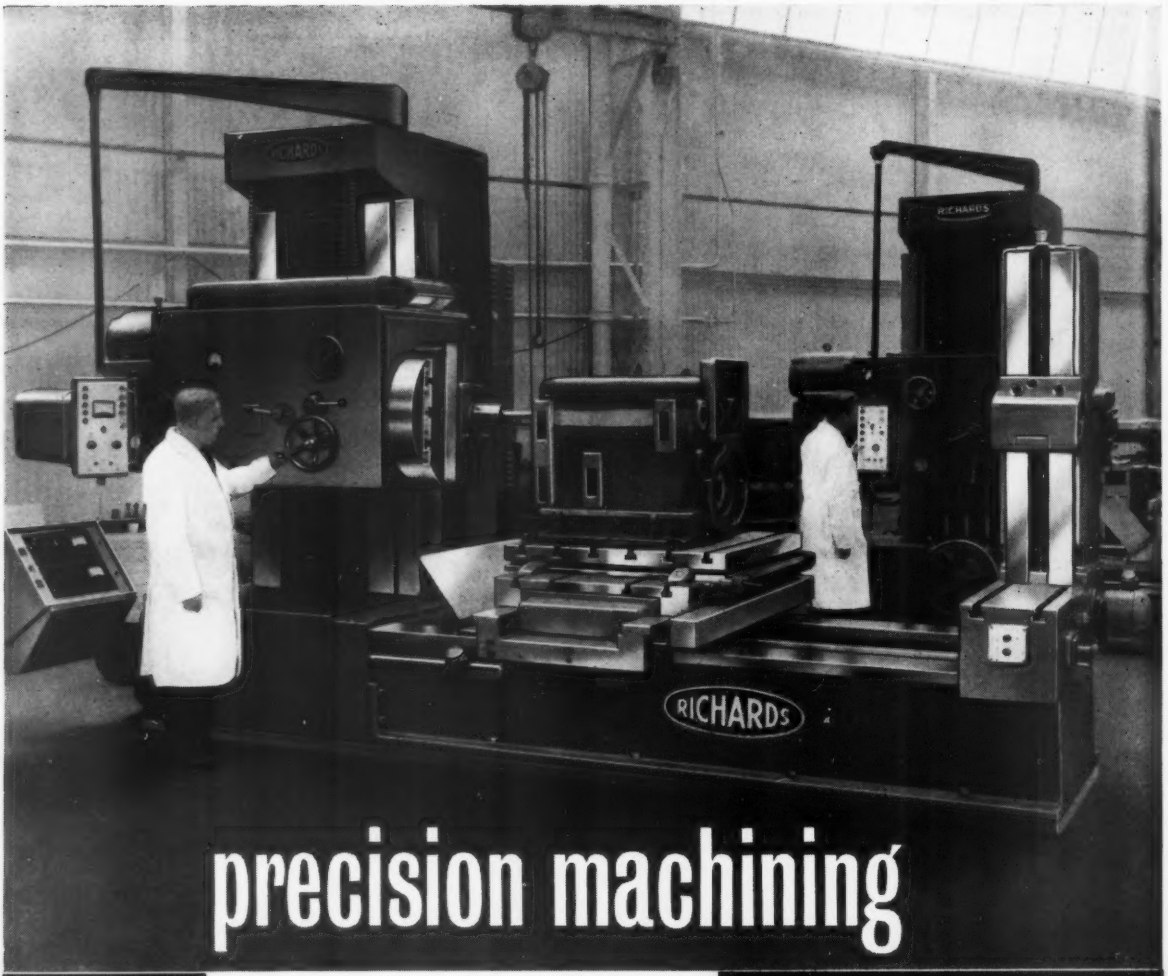
PHONE: BRIGHOUSE 627 (3 LINES) — GRAMS: 'WOODHOUSE BRIGHOUSE'

WM 33



precision machining

with RICHARDS automatic co-ordinate positioning

THE MACHINES ILLUSTRATED ABOVE ARE REPRESENTATIVE OF A FULL RANGE WHICH INCLUDE TABLE, FLOOR OR PLANER TYPE HORIZONTAL BORING MACHINES

The many outstanding features associated with Richards range of Horizontal Boring Machines include models with traversing spindles from 2½" to 7" diameter, facing capacities up to 72" diameter and in the case of the machine illustrated Richards Automatic Co-ordinate Positioning unit. All machines are designed to perform heavy duty milling and a wide range of bed lengths and widths are available. Further details are given in the new range of Richards leaflets, copies of which will be gladly sent on request.

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◀ **UNIT FAN HEATERS.** From 3 to 20kW for use in factories, shops, self-service stores and similar buildings particularly where floor space is limited.

NIGHTSTOR HEATERS. Use electricity at night when cheaper off-peak tariffs are available. From 1 to 3 kW. ▶

TUBULAR HEATERS. Available in various lengths up to 4-Way banks. A versatile type of heating for numerous applications. ▶

Write for publication H5 for full details of these and other space heating equipments.

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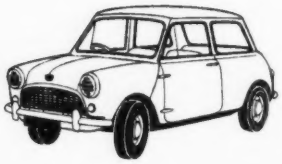
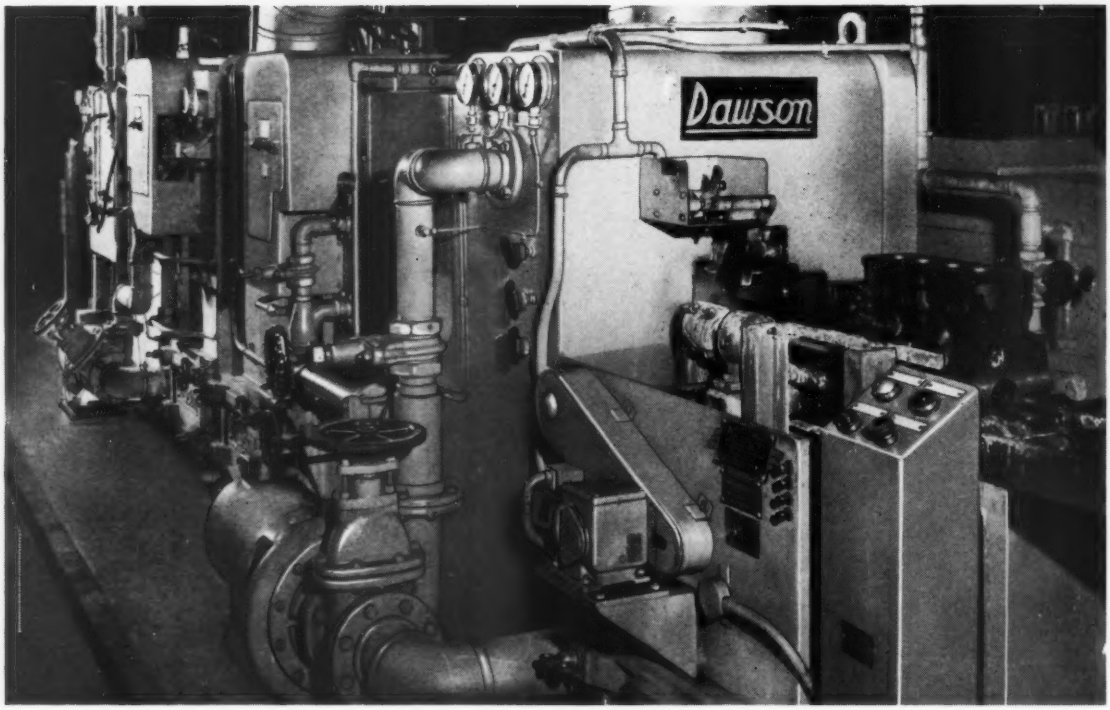
INDUSTRIAL HEATING DIVISION THE GENERAL ELECTRIC COMPANY LIMITED MAGNET HOUSE KINGSWAY LONDON WC2

Dawson Automatic cylinder block Washer for the new AUSTIN seven





The fully automatic Dawson machine illustrated is used to remove all cast iron swarf and cutting oils from the Austin Seven cylinder blocks before engine assembly. It is continuous in operation and handles up to 80 blocks per hour. The blocks are carried through the machine intermittently, pausing at each cleaning station in accordance with a controlled time cycle. An important feature of the machine are the swing type hydraulically operated jetting boxes (patent applied for) incorporated in the washing sections. Each of these has a main nozzle which is spring pressed on the main oil bore gallery at each end of the cylinder block, making a liquid tight connection. Thus the gallery is positively flushed from both ends, the liquid passing through all subsidiary ducts before escaping from the block. In addition, these jet boxes have secondary nozzles accurately registered with all the bores and recesses at the ends of the cylinder blocks.

This high precision cleaning plant is only one of the many Dawson machines installed in the Austin Seven production line.

Dawson

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LONDON WORKS, 406 Roding Lane South, Woodford Green, Essex. Tel.: Crescent 7777 (4 lines)

The right angle on the drive

E.N.V. are specialists in the design and manufacture of spiral bevel and hypoid gears, drives and assemblies, for which they have an exceptionally well-equipped plant.

E.N.V. Engineers will be pleased to advise on problems associated with gears and drives, especially where bevel gears are used.

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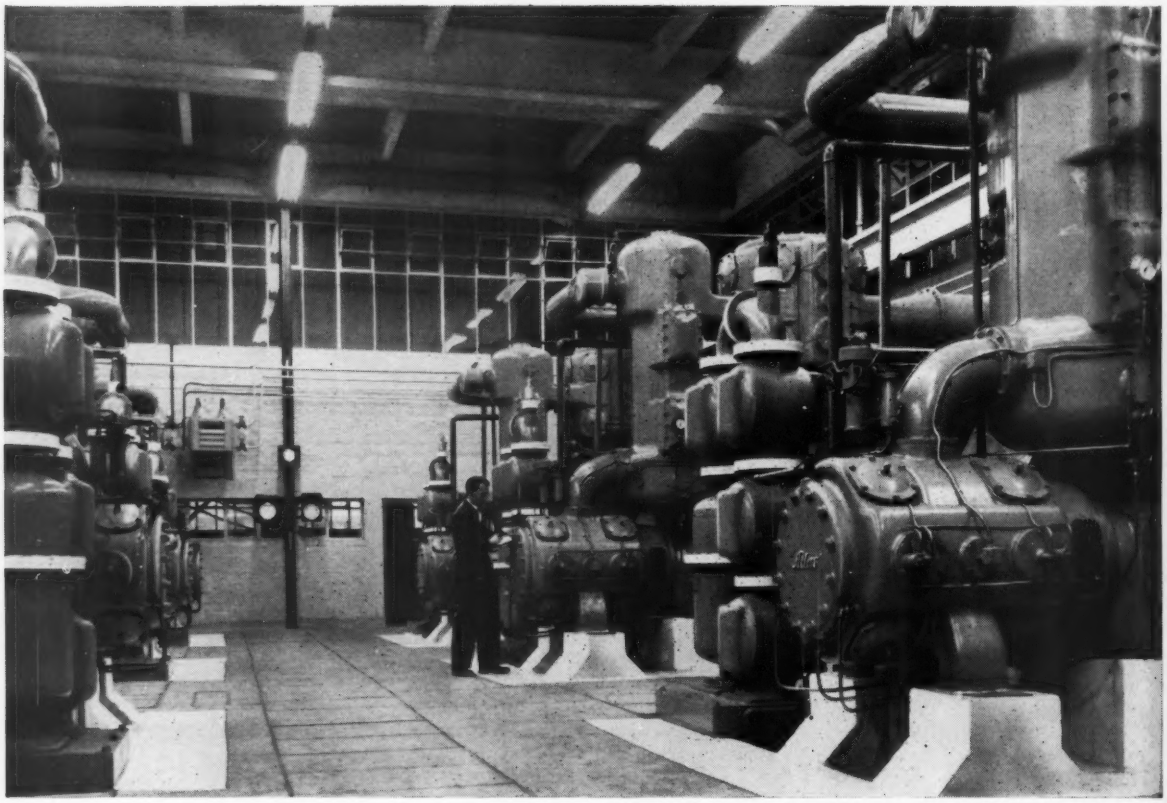

Some of the seven Atlas Copco AR9 compressors already in service with Vauxhall.

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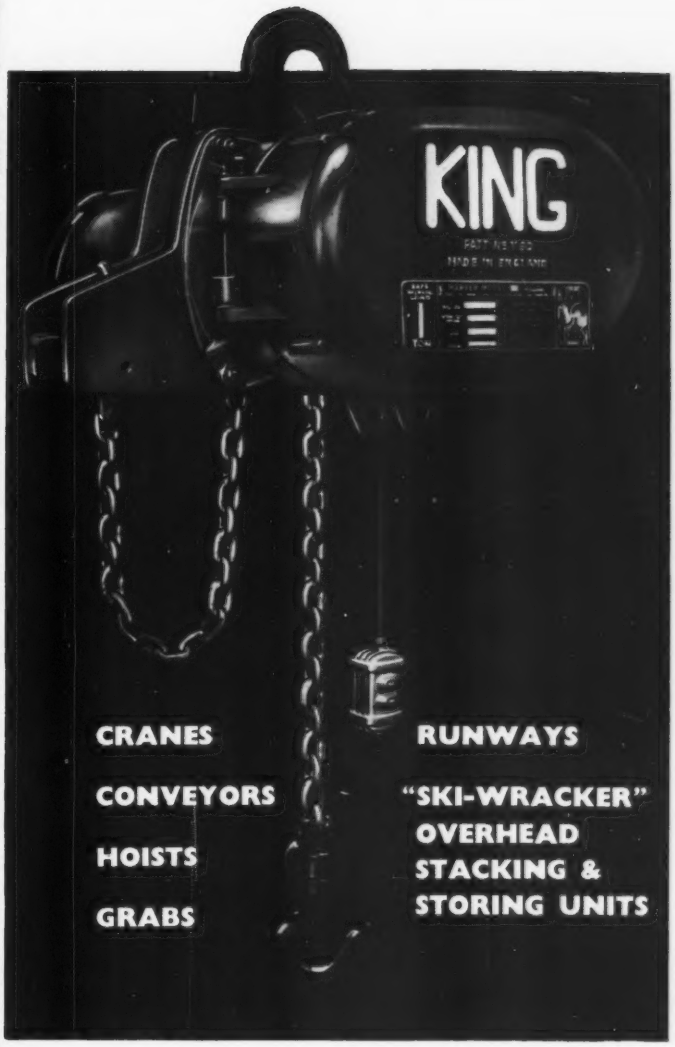

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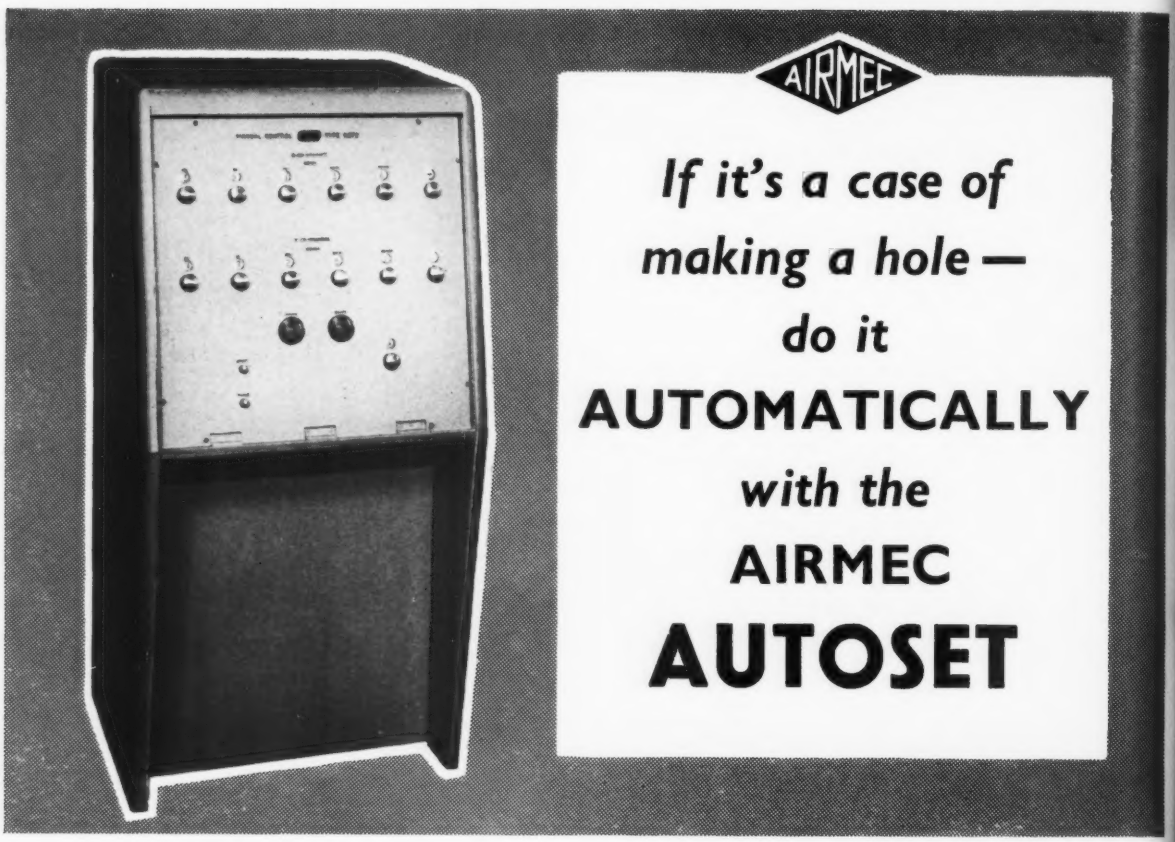

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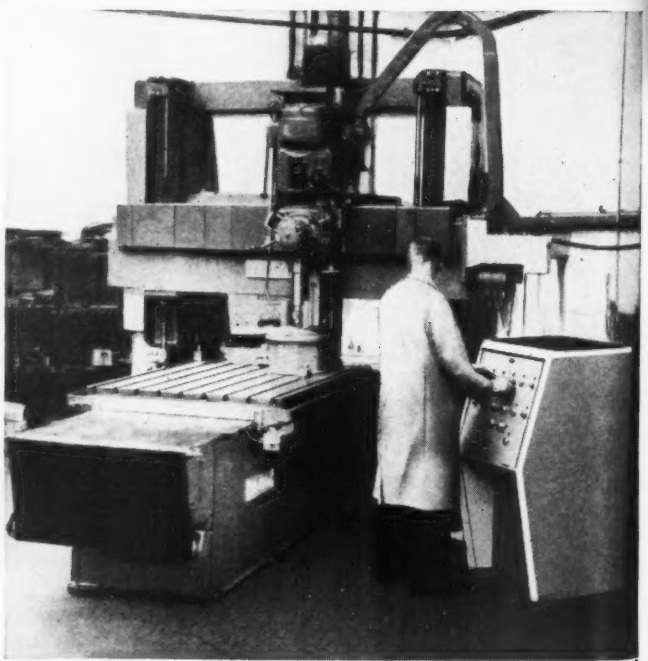

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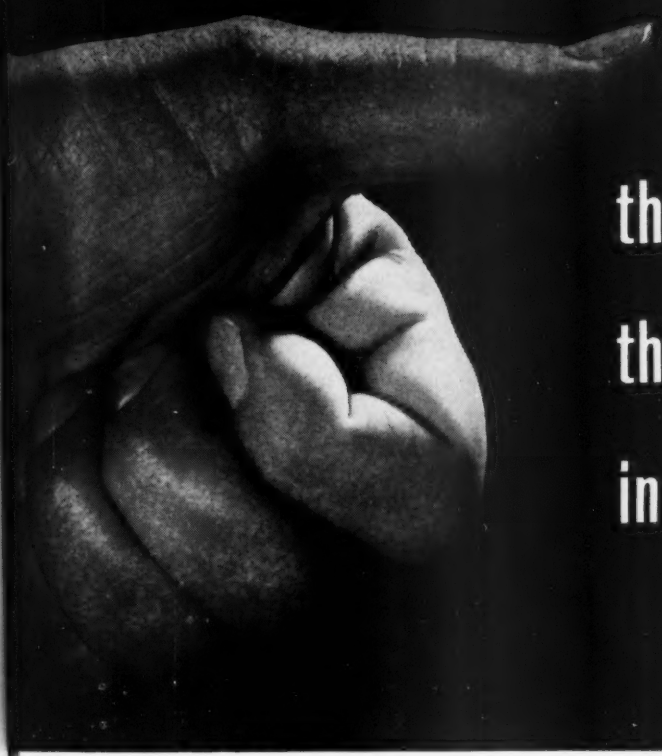

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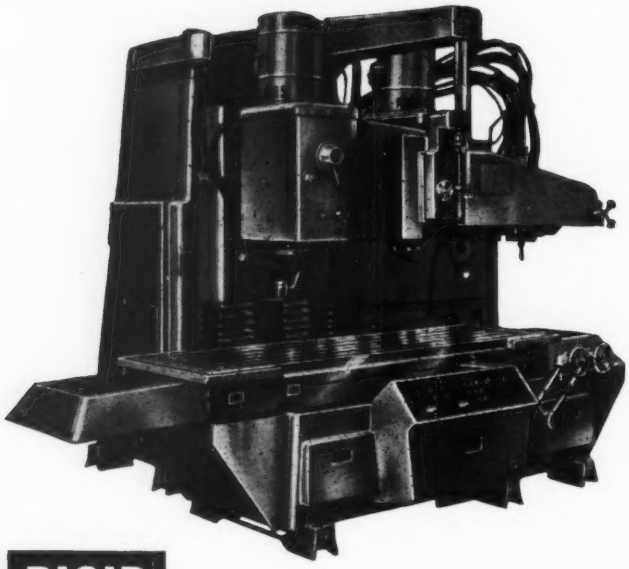

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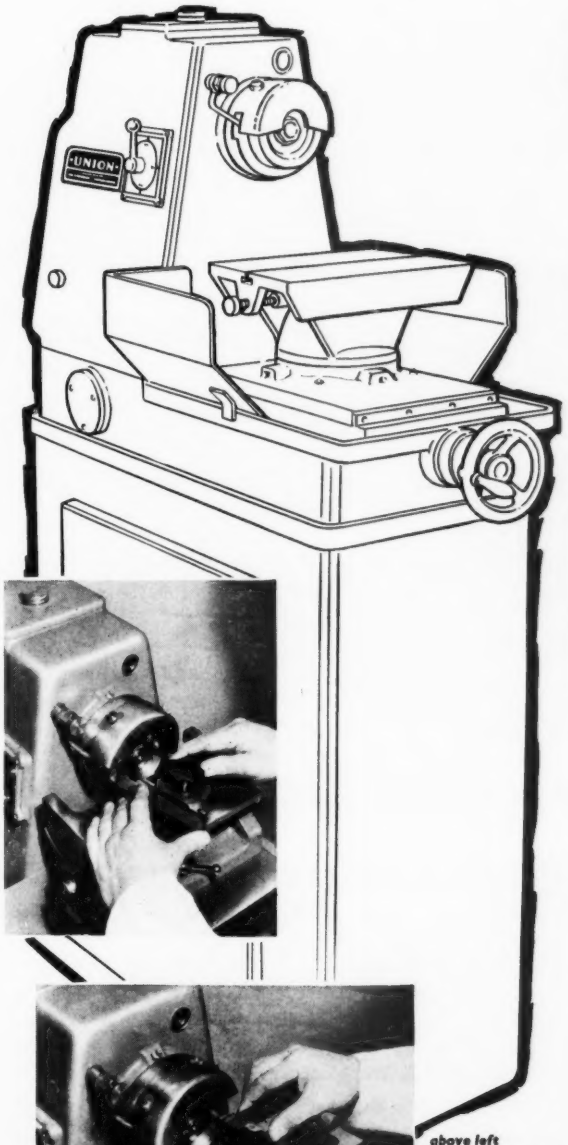

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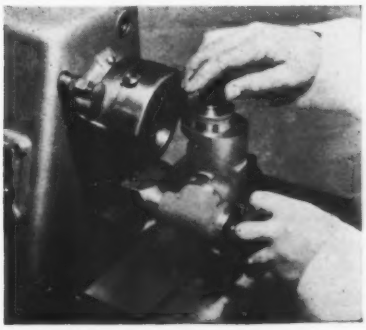

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Table can be inclined either way up to 20°. Tool guide moves 90° with accurately graduated base.

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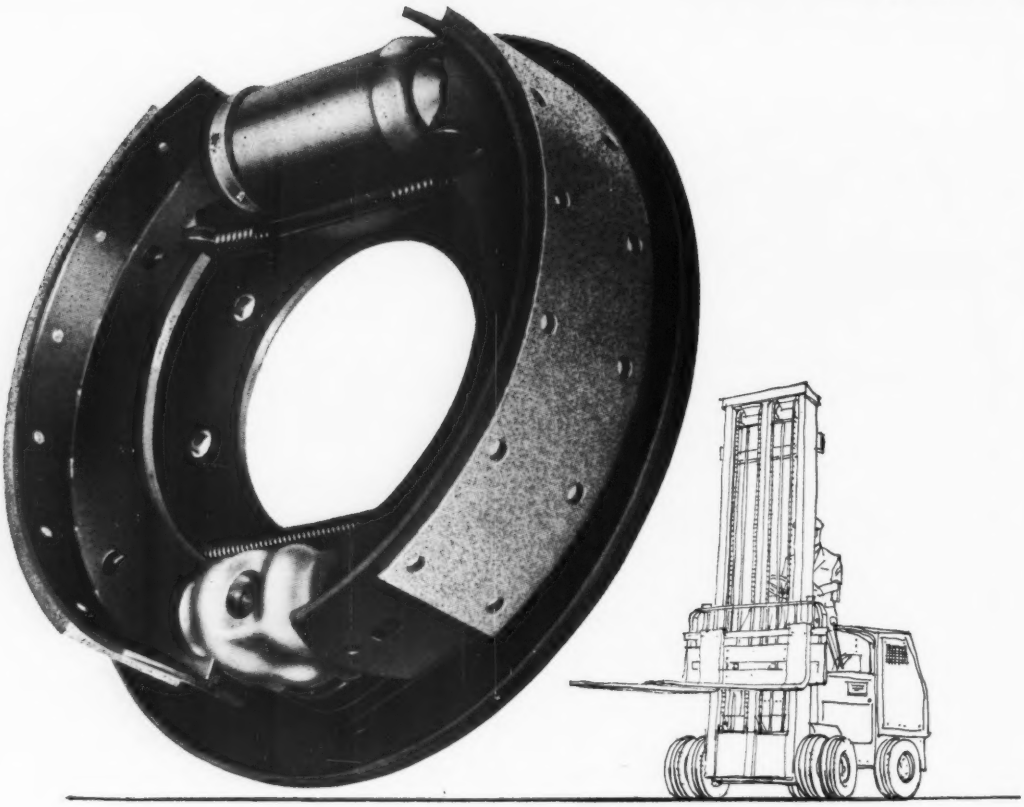

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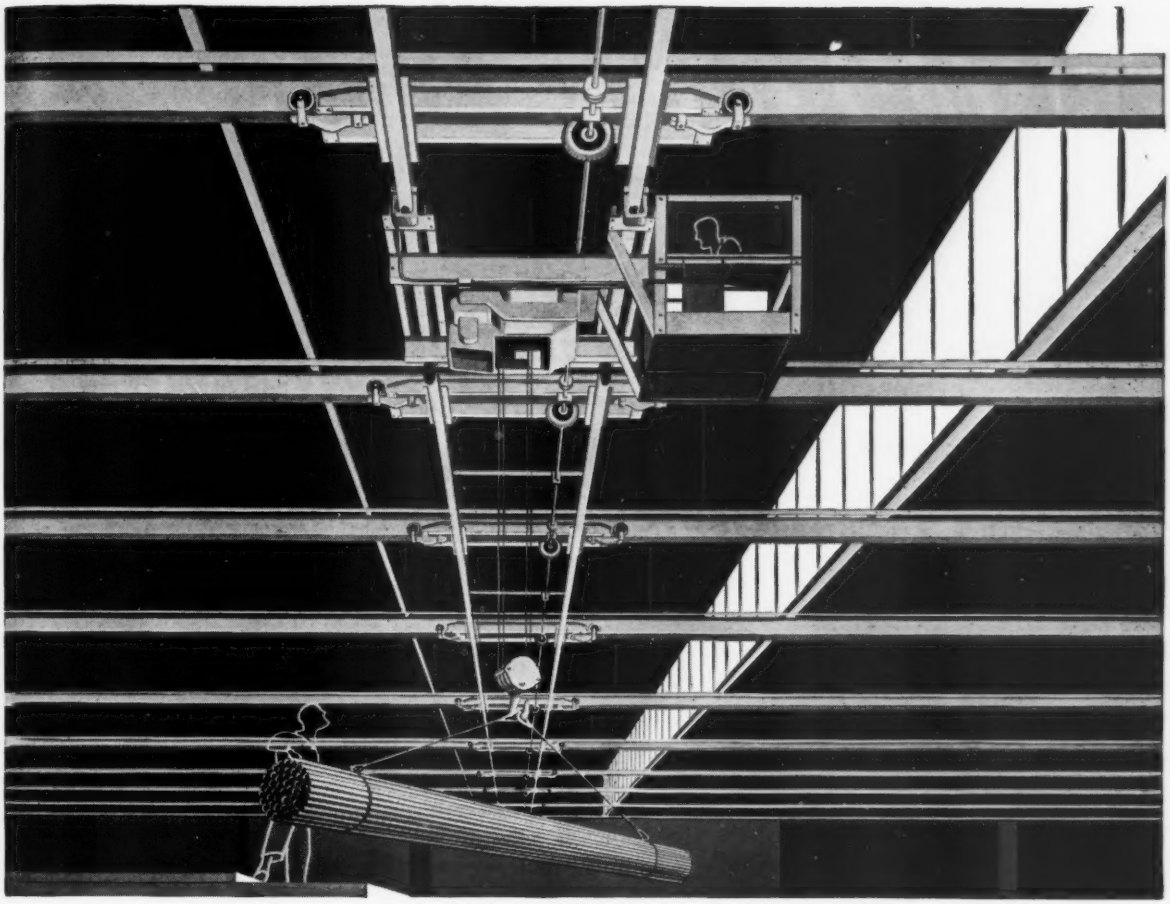

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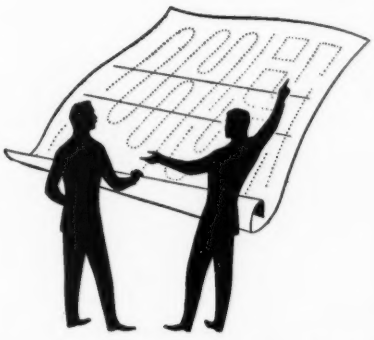

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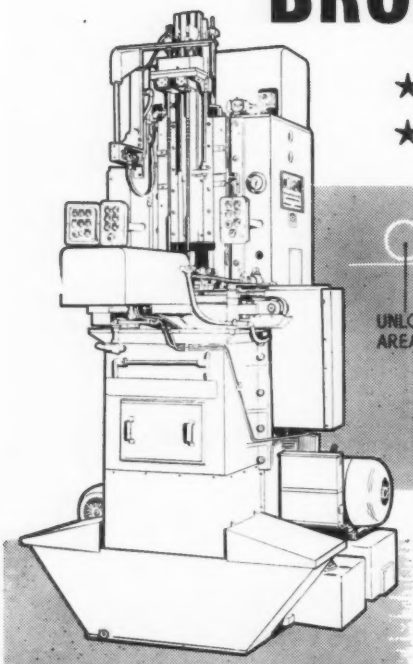
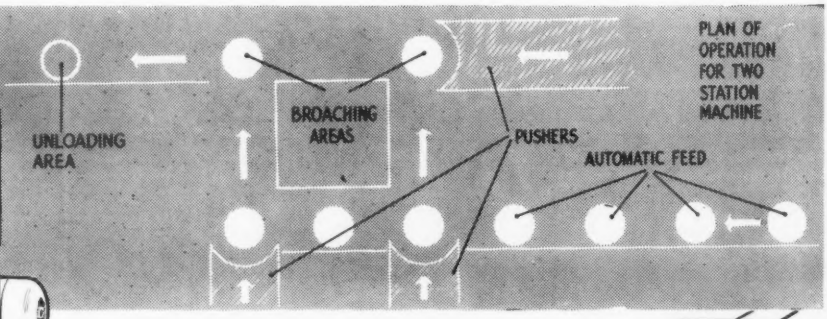
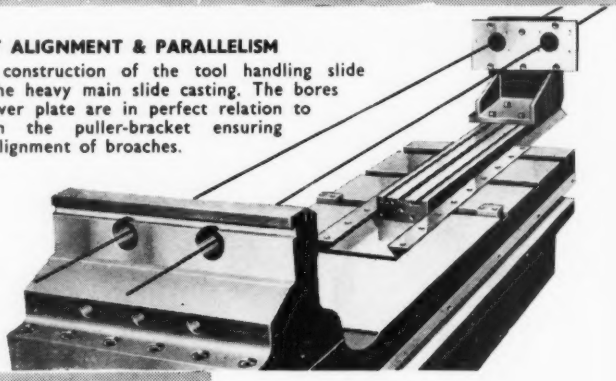




PERFECT ALIGNMENT & PARALLELISM
Integral construction of the tool handling slide within the heavy main slide casting. The bores in retriever plate are in perfect relation to those in the puller-bracket ensuring precise alignment of broaches.



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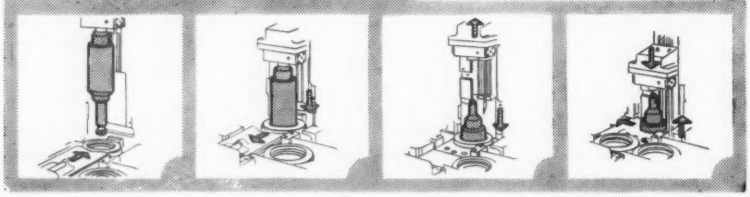

Part automatically positioned. Broach suspended.

Retriever lowered. Broach engaged in puller.

Broach passes through work; disengages from retriever when finish teeth have cleared the work.

Part automatically ejected Broach returning to upper bracket.

B.S.A. Detroit pull down machines have every feature for ease in operation and accurate production: automatic tool handling, unique and accurate guidance of broaches, continuous engagement at both puller and retriever end, single or multi-station operation, positive lubrication. Standard capacities: 5 tons, 30" stroke, 35 F.P.M., to 50 tons, 72" stroke, 20 F.P.M., (Cutting speeds variable). May we supply further details ?

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OIL-SEALED ROTARY COMPRESSORS

FROM 1/3-250 H.P.

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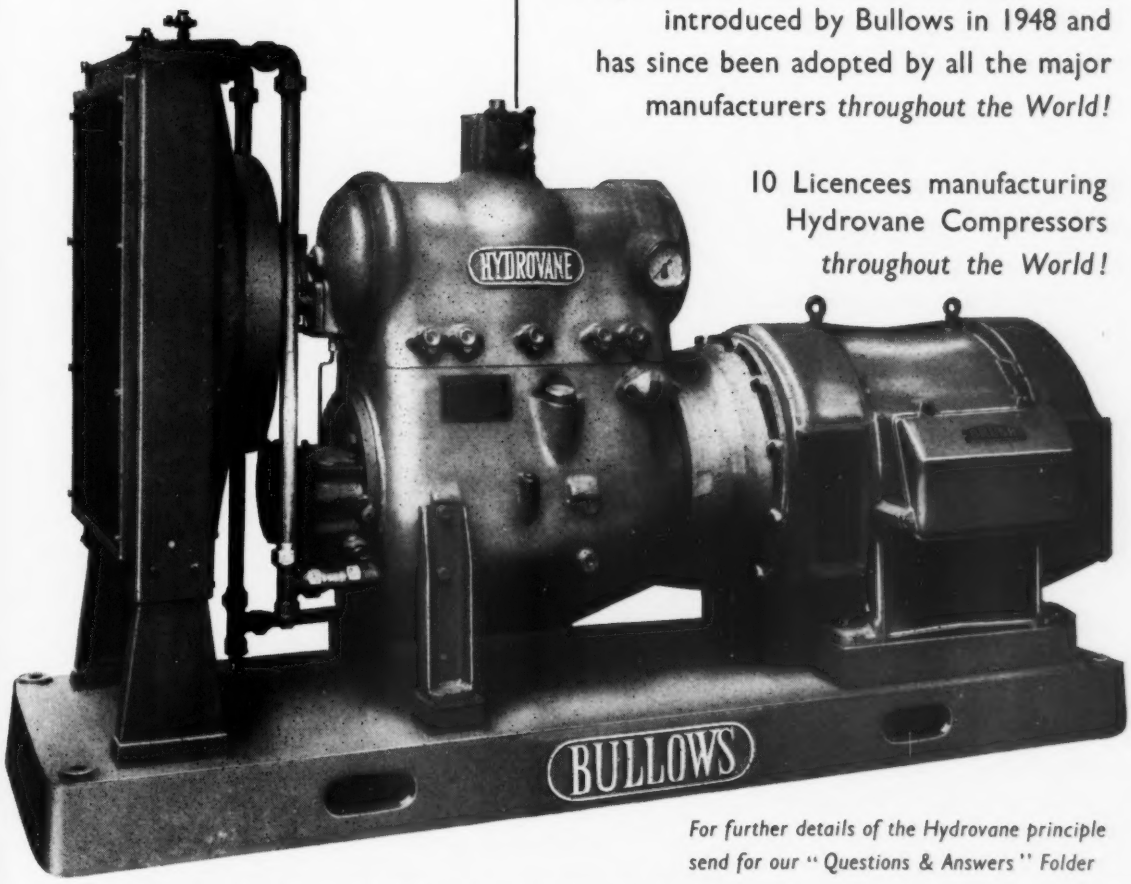

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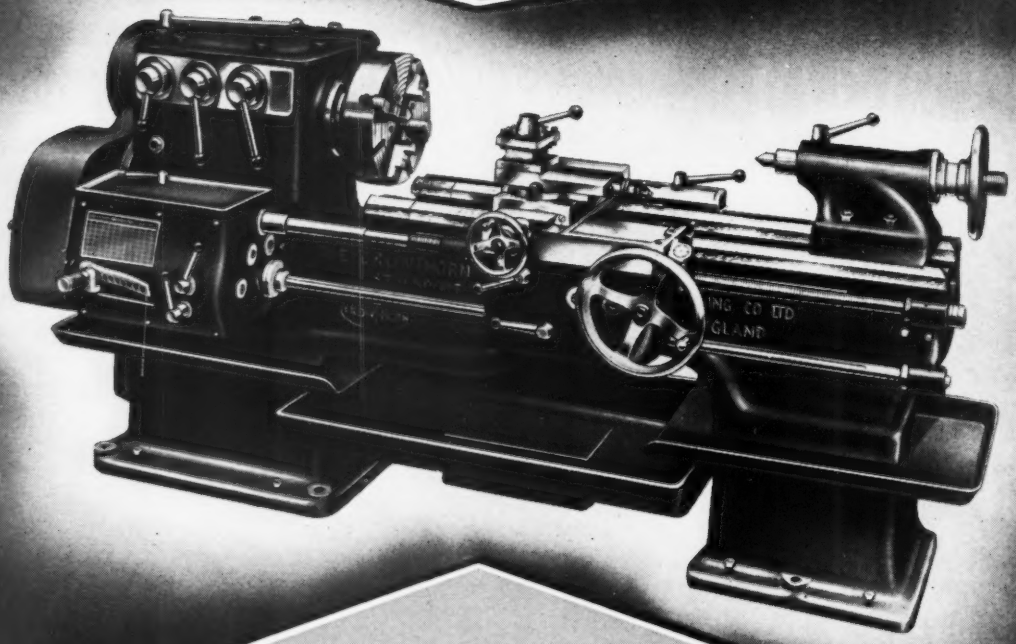

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* Gamet micron precision bearings.
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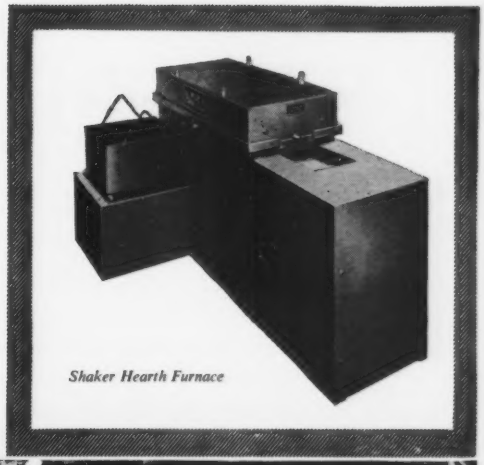
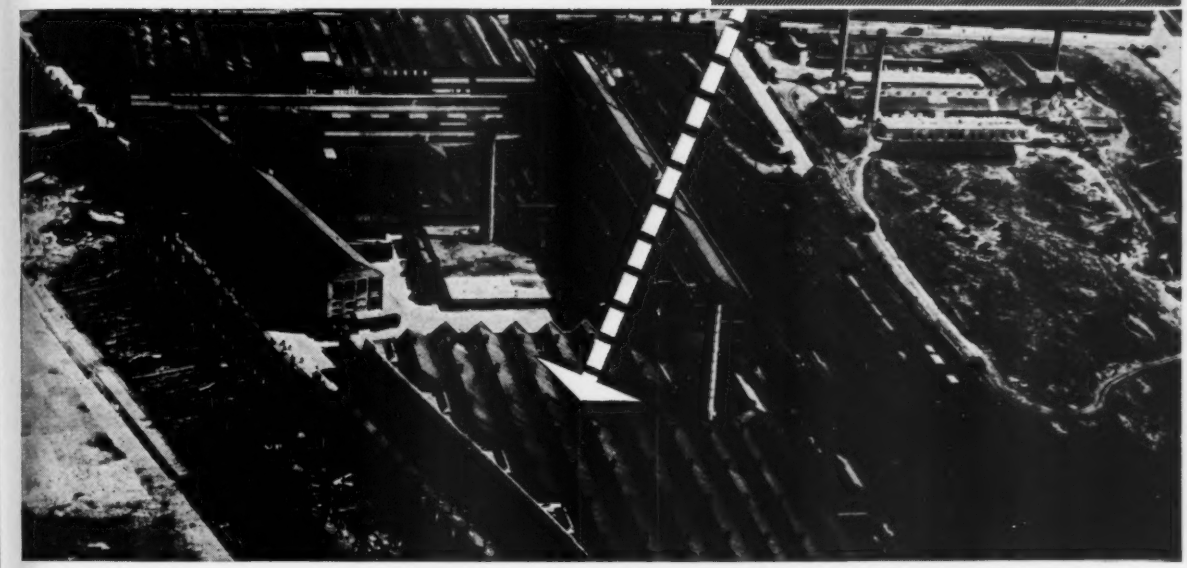


Shaker Hearth Furnace



A Wild-Barfield furnace will bring immediate advantages. It speeds up production and helps to cut costs by eliminating delays and wasteful handling. Built to the highest standards of workmanship, these furnaces offer consistent results and minimum maintenance. The Wild-Barfield Research Department is available at all times to advise you on your heat-treatment problems.

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WB 61

STRIPPIT *tooling versatility*

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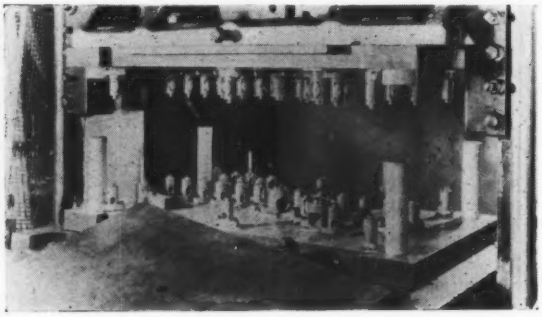

For unlimited feeding of work, Strippit Type CD and JD (heavy-duty) Punch and Die Assemblies are readily template-mounted to press ram and bed in any desired pattern.

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Also, 90-degree Corner Notching Units in 3" x 3" and 5" x 5" sizes, plus V, Radii and many special shape notching units. Capacities to ⅛" in mild steel.

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Electrical Aids in Industry *Data Sheet* **No. 12**

Dielectric Heating - 3

Some further details of the uses to which dielectric heating can be put are given in this data sheet, being continued from data sheet No. 11.

The Woodworking Industry

A most important development in recent years in the woodworking industry has been the introduction of synthetic resin adhesives of the thermosetting type for the bonding and adhesion of wooden components.

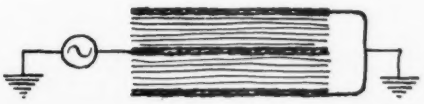
Setting of these resin adhesives proceeds at a rate largely determined by temperature. For instance, urea formaldehyde, one of the resins in common use, sets as follows:

TEMPERATURE	SETTING TIME
65°F	3 hours
80°F	1 hour
150°F	3 minutes
190°F	1 minute

The resultant bonded joint is equally satisfactory in each case. Most of the power supplied when dielectric heating is used is absorbed by the resin, the heat thus being concentrated where required and power consumption reduced to a minimum.

Plywood

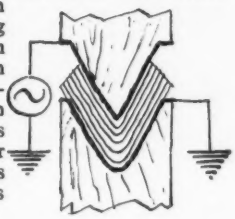
With dielectric heating consuming power only during the heating cycle, plywood can be produced with considerable savings in heating times and costs.



For example, in a press holding 100 3-ply ½" thick assemblies, the resin glue is set in 20 to 30 minutes, depending upon the dryness of the wood. An output of up to 60 cu. ft. of plywood is obtained per hour using a 25 kW H.F. generator.

Curved Laminated Sections

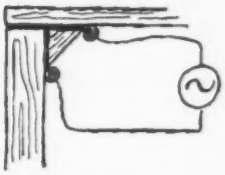
Curved laminated sections are being increasingly used in contemporary furniture, and with dielectric heating rapid production can be achieved using wooden shaping blocks in single daylight presses. An alternative method of providing heat by conduction from heated metal strips becomes increasingly slower as the total section thickness rises above 0.05 inch, as shown below:



TOTAL THICKNESS OF LAMINATIONS	*Comparative heating times in minutes*	
	CONDUCTION	DIELECTRIC
1 inch	20	4
⅜ inch	5½	2½
0.6 mm veneer	1	1¼

Furniture Assembly

Because of the savings in glueing processes already instanced, dielectric heating is being extensively used in the furniture trade. It leads also to reductions in labour and floor space, with the elimination of assembly jigs. The heating equipment can be placed directly in the production line, cutting handling to a minimum.



Resin-bonded Wood Chipboard

A substitute for natural timber is made from wood waste and chippings, broken down to a coarse size, mixed with synthetic resin and heated under pressure. Dielectric heating gives quick and uniform heating, and increased fluidity reduces the power required for the final pressing and curing operation. In a continuous process, the length of the press required is also reduced.

Blockboard

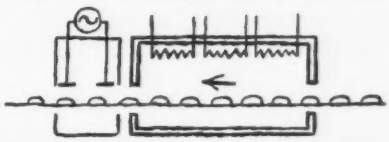
Production of blockboard by edge glueing strips of wood also provides an excellent use for dielectric heating, since considerable savings in time and labour can be effected owing to the large areas of glue line involved.

Other Resin-bonded Products

Dielectric heating is also used in the manufacture of other resin-bonded or impregnated products such as grinding wheels, impregnated woods, fabrics, felts, glass-fibre and similar products.

Foodstuffs

Increased use is being made of dielectric heating in many processes connected with foods; these include de-freezing and melting, sterilisation and disinfestation, drying of breakfast cereals, dog biscuits, rusks etc., heating of nuts to facilitate shelling and other similar types of application. Although some cooking processes are technically



possible, as for example bread baking, the 'unbrowned' product has so far proved unacceptable to the public and a completely dielectric process uneconomical. When combined with conventional baking, however, as now in the biscuit trade, where dielectric heating is being used to complete the baking of biscuits, it can produce normal biscuits in ⅓ to ½ the usual baking time.

There are in fact so many potential applications of dielectric heating (and these applications are increasing daily as the chemical industry develops new products, as for example synthetic fibres) that the selection given in the present series of data sheets covers only a part of the whole field.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example.

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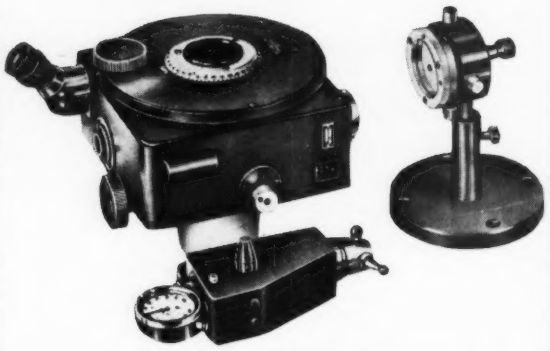

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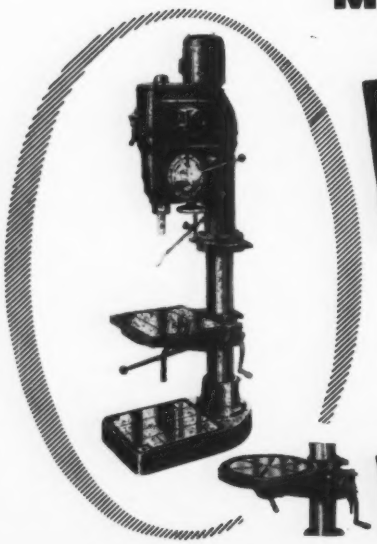

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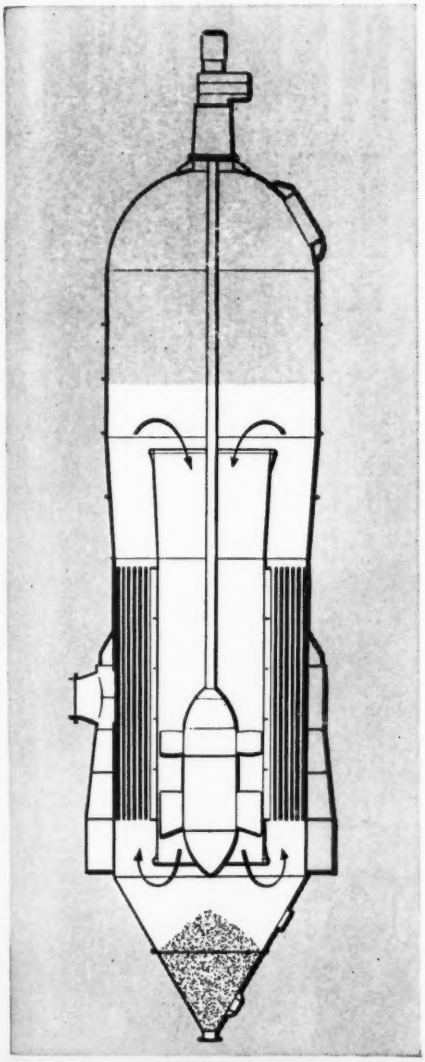

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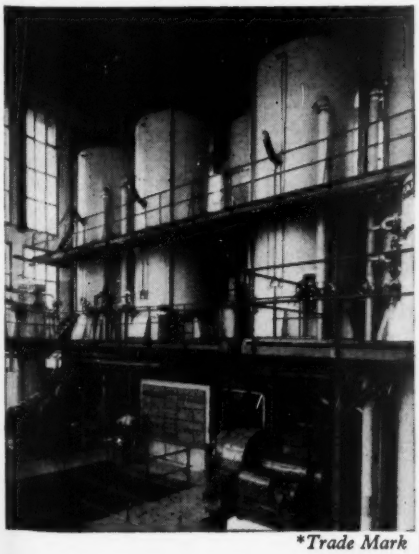
Diagram of a typical Escher Wyss brine evaporator.



Main hall of the United Swiss Rhine Saltworks plant at Schweizerhalle, showing Escher Wyss evaporators connected in series. Monel and steel clad with Monel alloy are widely used for parts in contact with the brine.

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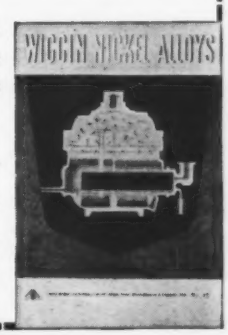

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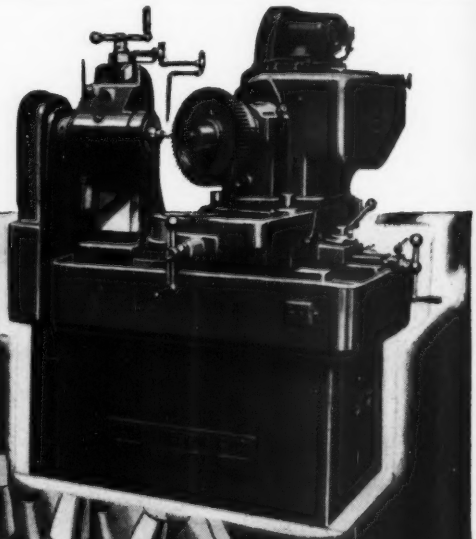

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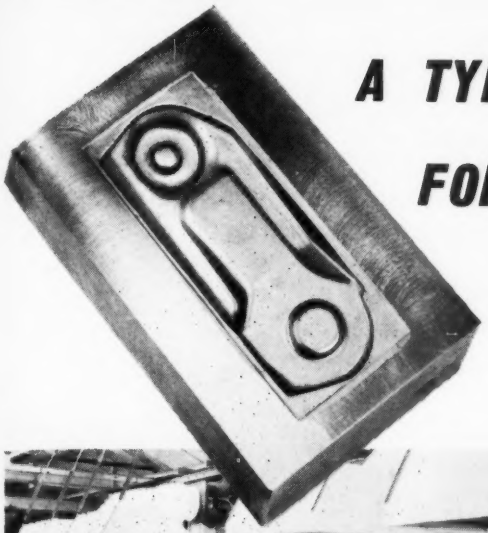
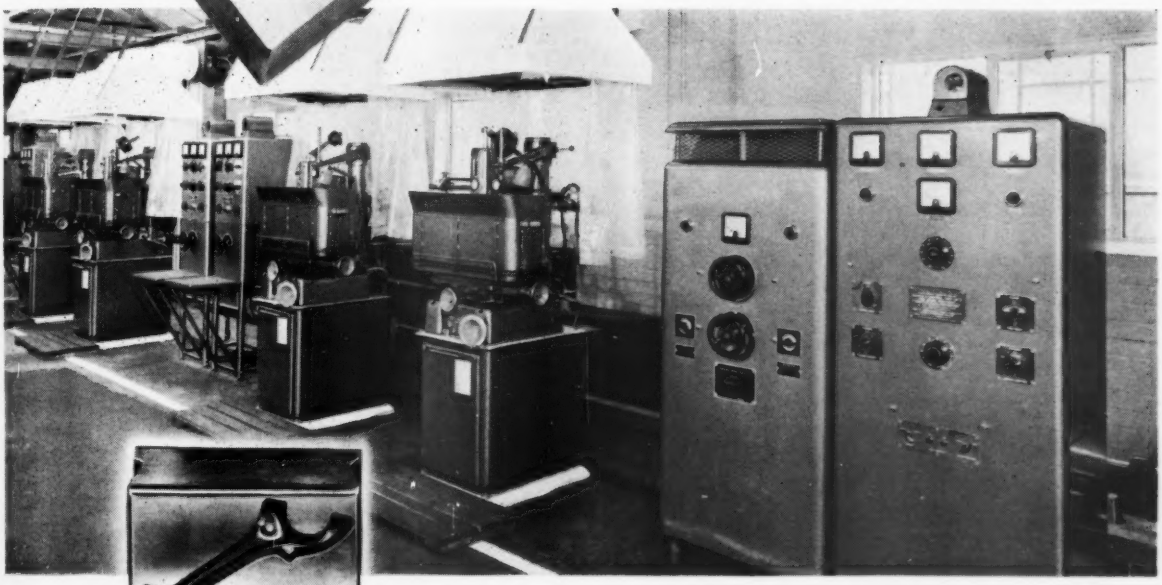
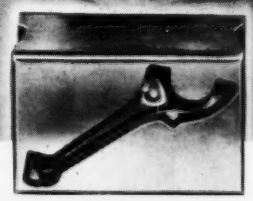


A TYPICAL PRODUCTION SET-UP FOR HEAVY DUTY TWO-STAGE SPARK MACHINING





The R.I.G. may be used in conjunction with the Sparcatron Mark III mechanical portion, and means are provided so that the Mark III power pack can be switched in for finishing. In this way the spark machined surface from the R.I.G. can be quickly brought to the normal non-directional matt finish commercially acceptable which thereby eliminates benchwork and pre-machining by conventional means.

The examples shown were machined from the solid in times comparable with those obtainable by conventional methods, the roughing being carried out on the R.I.G. circuit and switching over to the standard Sparcatron Mark III for finishing.

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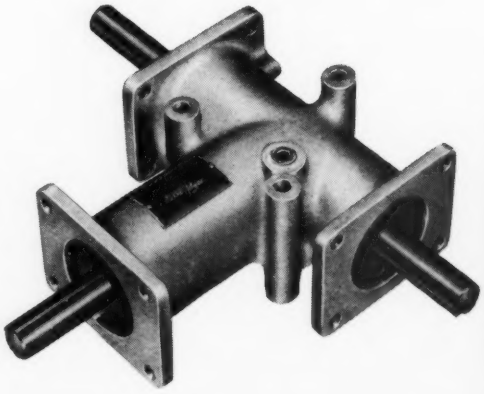

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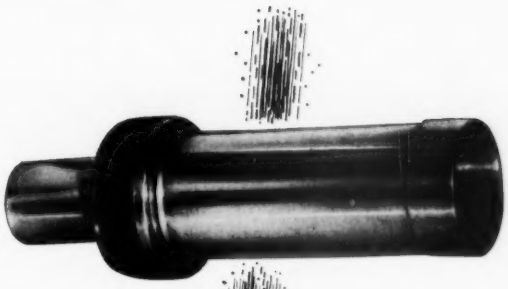

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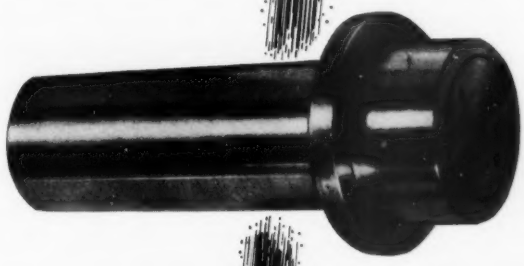

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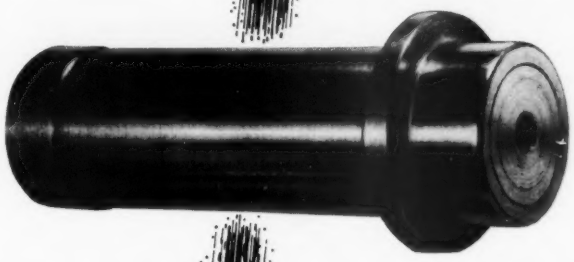

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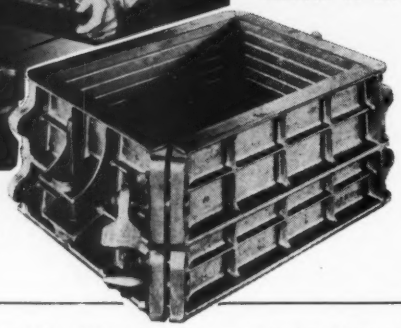
Wadkin Articulated Arm Router L.C. face milling the end plates of the Sterling slip flask shown right. Photographs are reproduced by courtesy of Sterling Foundry Specialties Ltd., Bedford.



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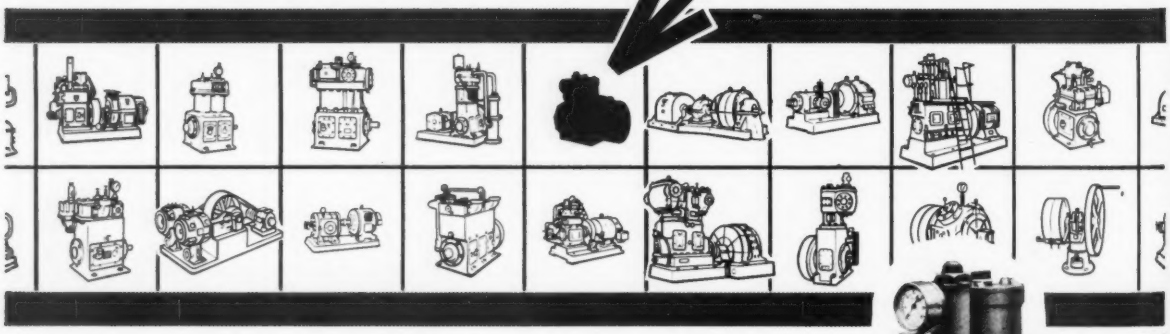

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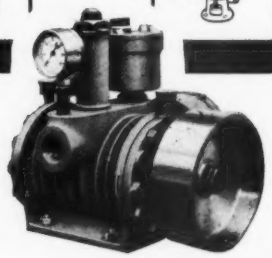

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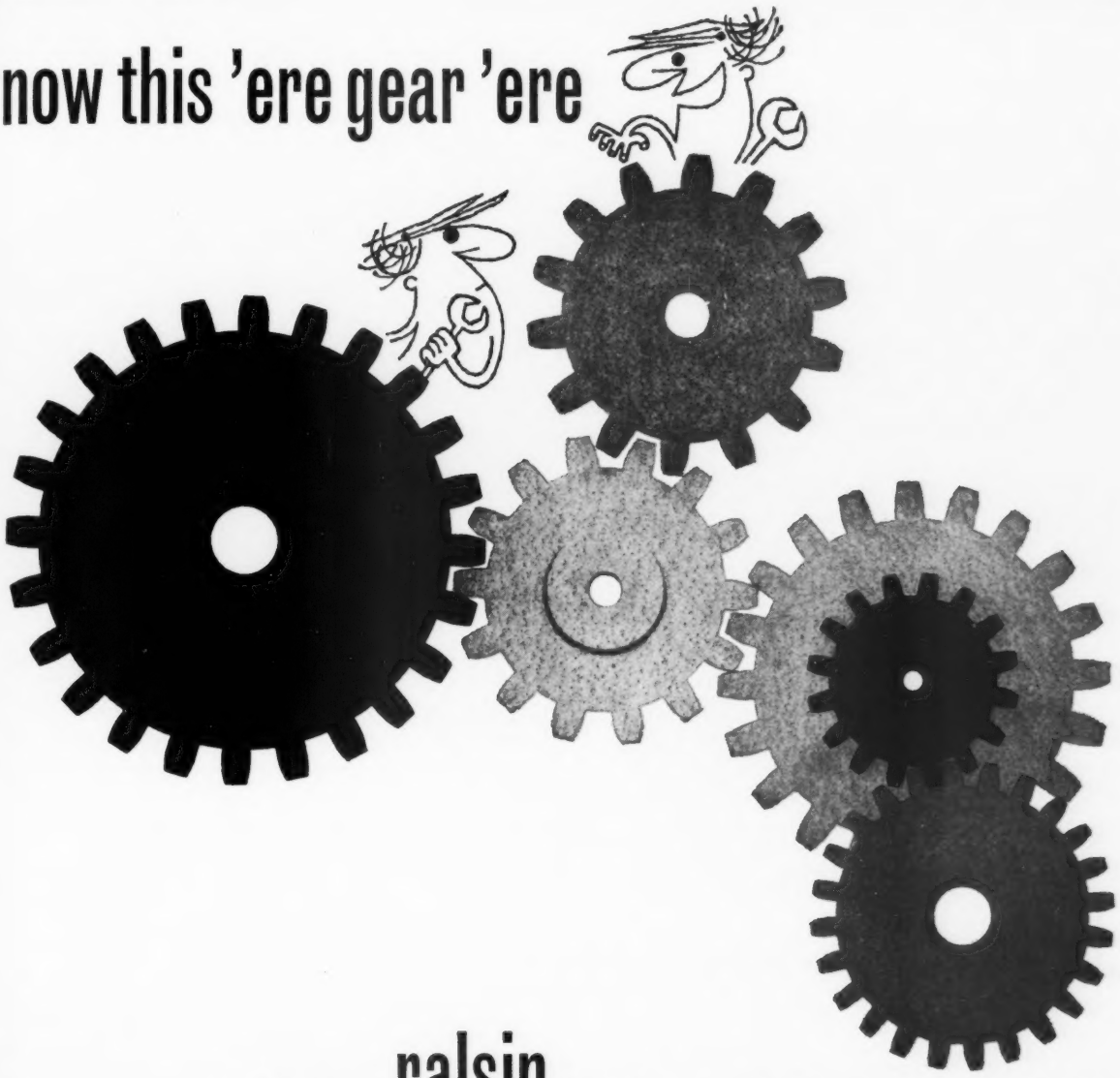

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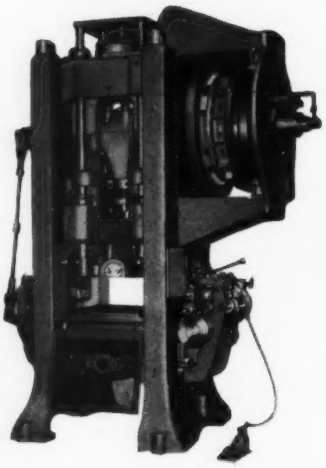

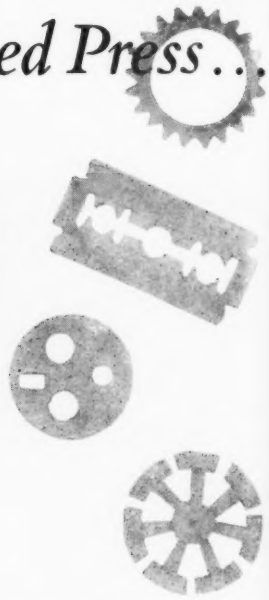

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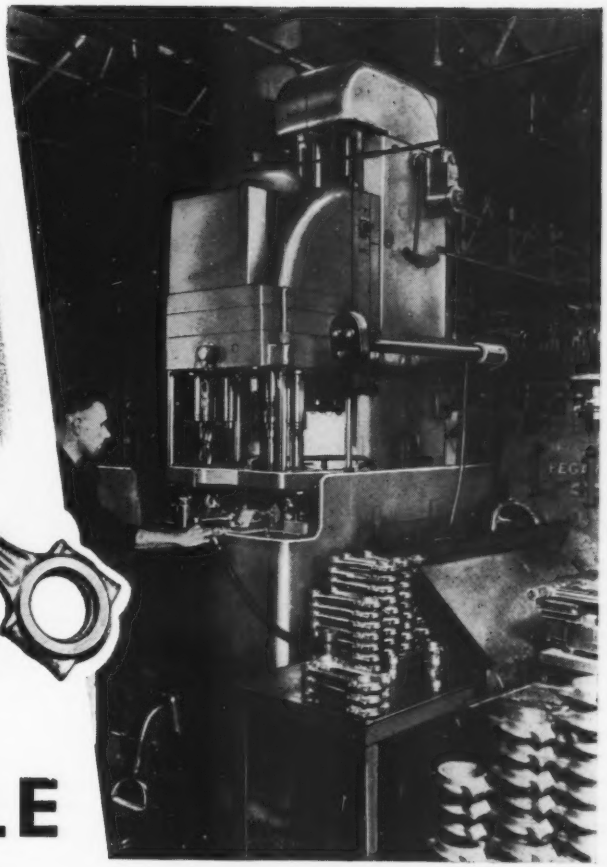

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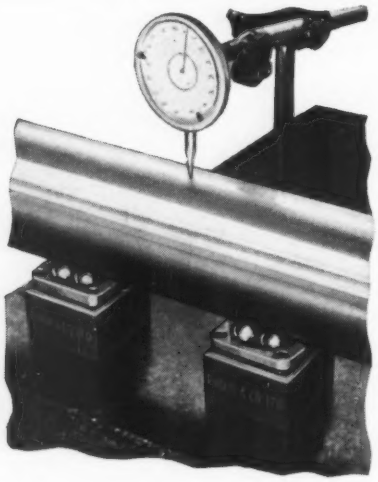

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3	1½ in.	95	£23. 5.0

Model BB including clamp
(can be used on any side)

Order No.	*Per Pair*
96	£8.10.0
97	£13.10.0
98	£34. 5.0

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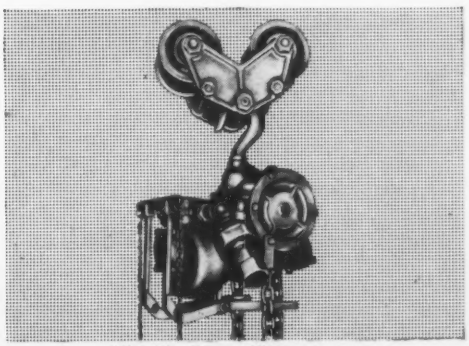
At the Massey-Ferguson tractor works in Coventry, compressed air plays a leading role in production. Compressed air drills, rivets, runs nuts and screws, sprays paint, locks jigs and operates pneumatic safety guards. But above all, compressed air lifts and lowers. Two hundred air hoists lend smooth, controlled power to each necessary vertical movement of every tractor component weighing 40 lbs. or more—at every stage of its journey along the production line to final assembly.

Four years ago Massey-Ferguson installed their first Atlas Copco air hoists. Now they are operating many Atlas Copco MT505 8 cwt. hoists and a number of the big 30 cwt. MLT31K. The service record of these Atlas Copco hoists is impressive. They have proved consistently reliable, trouble-free and unaffected by steam, heat or water. They have proved, moreover, to combine this rugged capacity for continuous hard work with extremely sensitive control. In the words of a Massey-Ferguson spokesman: *For the many delicate operations involved in the mass production of tractors, we needed a hoist that could be operated within fine limits, with a range of speeds to give us real flexibility.* Atlas Copco air hoists have met that demand—more fully than any other existing form of hoist could have met it.

An Atlas Copco air hoist offers up a tractor wheel precisely to the studs. In a matter of moments, an Atlas Copco impact wrench will have run up the nuts.



The Atlas Copco MT505 air hoist.

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steady

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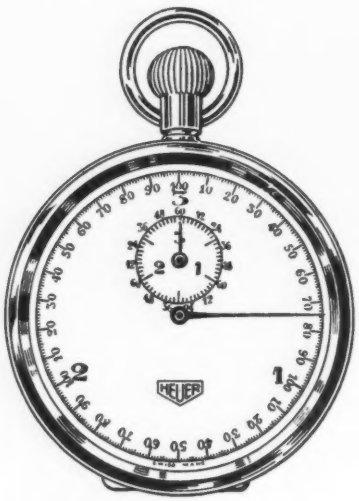
stop

Process-Time recorded: one and one-hundredth seconds. With timing to the hundredth of a second by Heuer.



HEUER timers

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Kollercast

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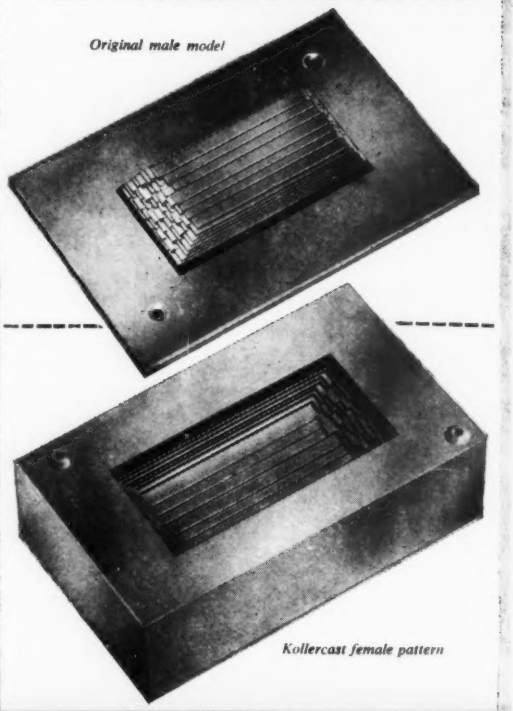

Kollercast female pattern

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PLUS ONE CAN KOLLERCAST HARDENER

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ROOM TEMPERATURE HARDENING

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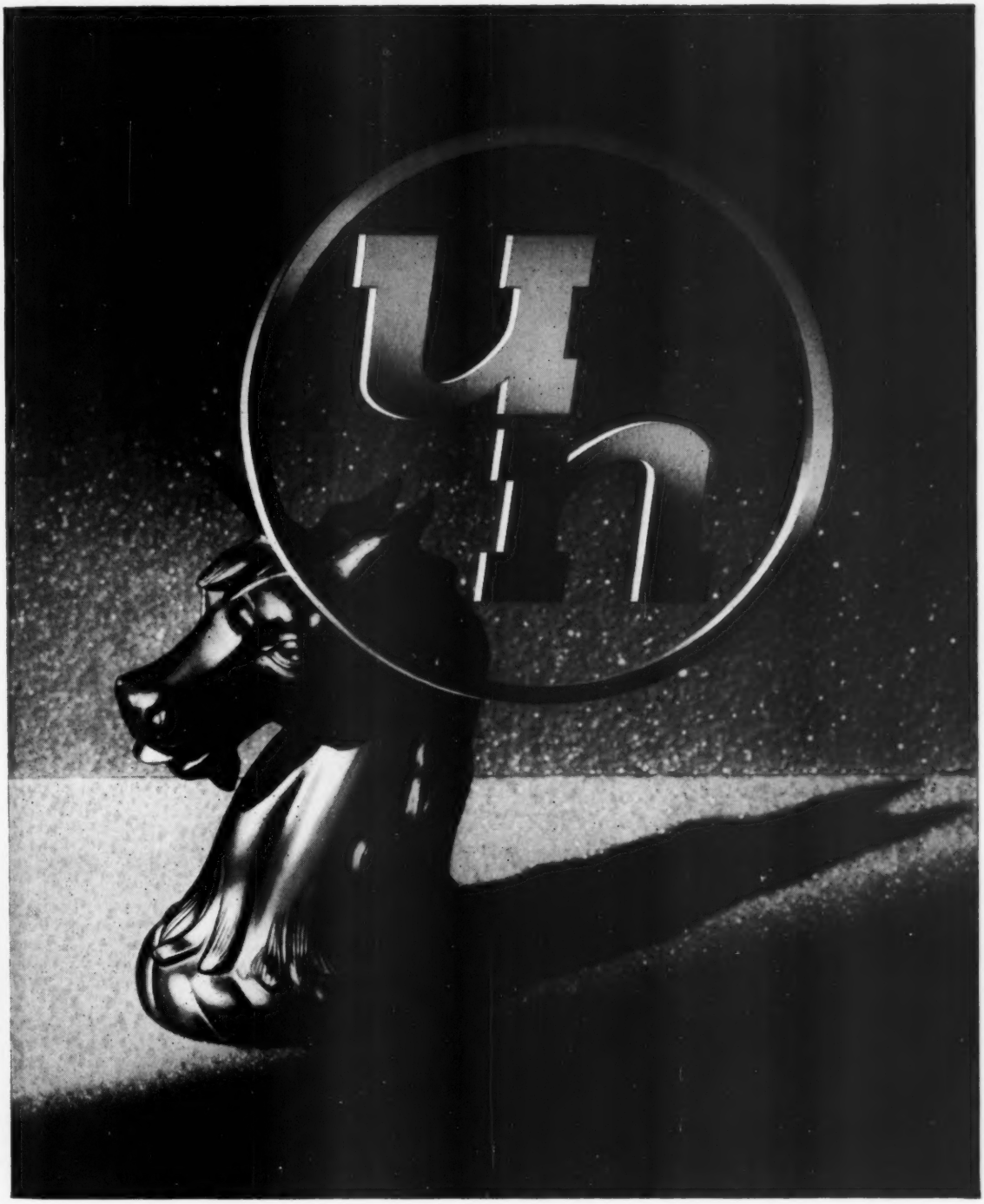

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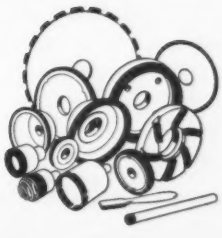

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DISTRIBUTED BY **UNIVERSAL GRINDING WHEEL COMPANY LIMITED · STAFFORD**

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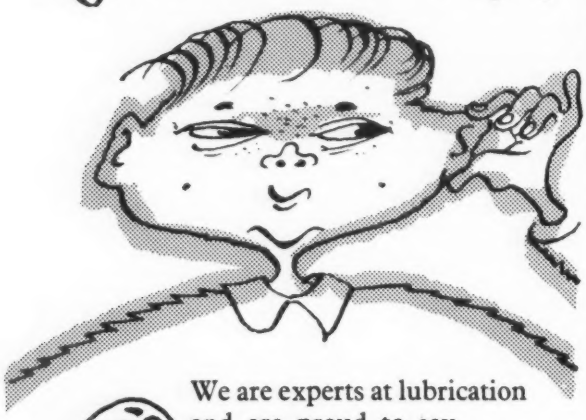

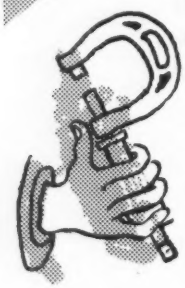

We are experts at lubrication and are proud to say we usually gain full marks for our endeavours. If therefore, you have a mechanical problem child in your works, it will give us much pleasure to smooth its path.
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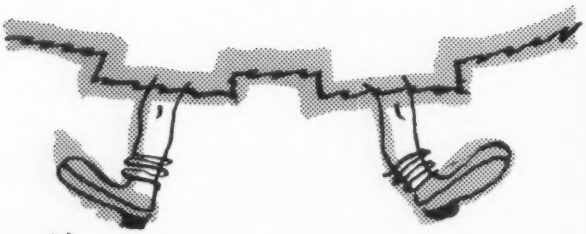

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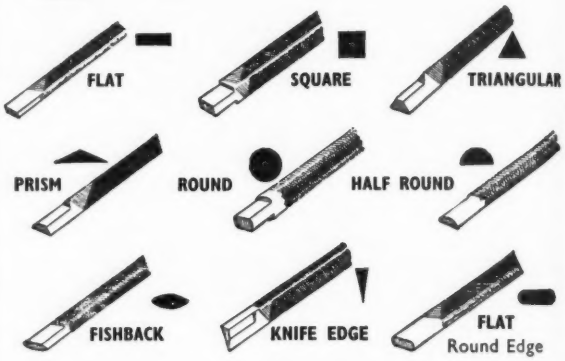

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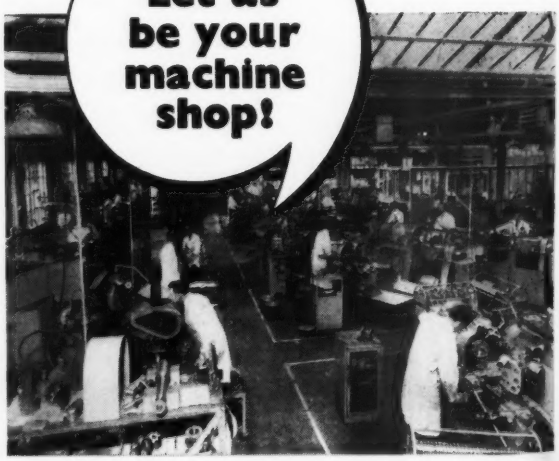

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. . . as well as shaping, honing, drilling, tool-making, etc. to meet your every need. A·I·D & A·R·B Approved

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that locks the fastening
permanently
against shock and vibration;
in any position;
and without reducing
its strength.
Made of tough
resilient nylon,
Wedglok is quite
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solvents, age,
or temperatures
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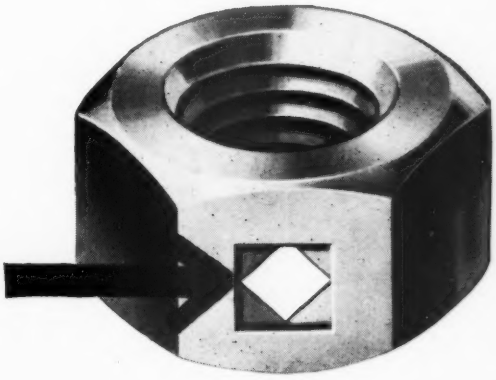

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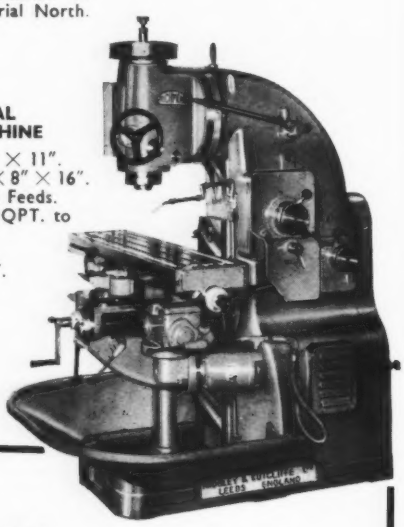
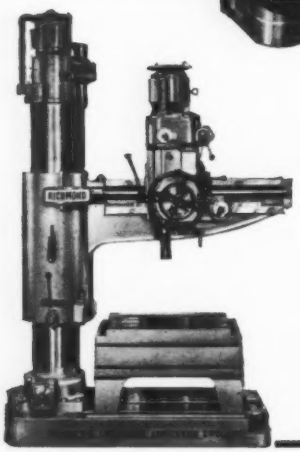
No. 3 VERTICAL MILLING MACHINE

Table Size : 48" × 11".
Capacity : 30" × 8" × 16".
12 Speeds — 12 Feeds.
Automatic and QPT. to all motions.
Spindle Bored No. 40 B.S.S.T.
Head Swivels 45° Right or Left
3" Vertical Spindle adjustment.





H.B. 3/12 RADIAL DRILLING MACHINE

12 Spindle Speeds 20 - 960 R.P.M. or 40 - 1800 R.P.M.
4 feeds — .004 to .013 ins./rev.
Pillar dia. 12".
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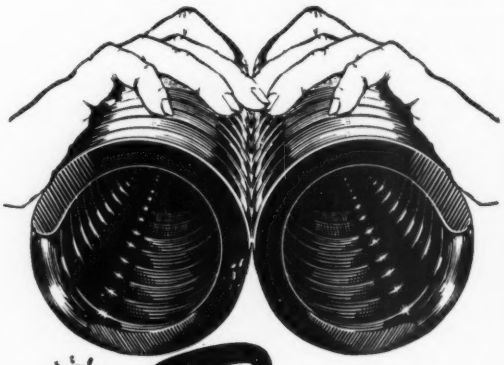

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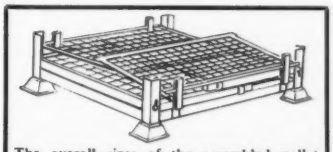
The Watford Printing Works of the Ever-Ready Co. (Great Britain) Ltd. handles all forms of cut-to-size battery components and a wide variety of printed labels and cartons, the annual output being 4,000 tons. The necessity for frequent replacement of corrugated containers for internal and outside transport made handling costs high. So Ever-Ready consulted Rubery Owen. Now, as a result of careful study by R.O. experts, a pallet system has been installed which, over a period of 15 months, has already shown a saving of nearly £5,000.

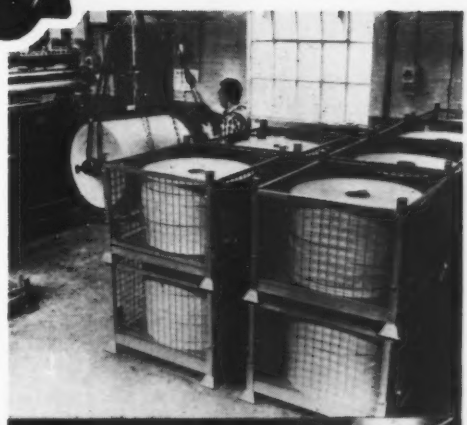
The pallets supplied, 2,000 in all, are of the collapsible type and the accompanying photographs show them in use in various parts of the works.

Rubery Owen Industrial Storage Division operate a complete service in palletisation and are one of the largest manufacturers of this type of equipment in the country. Pallets are produced in a wide range, either of conventional design or of special character to suit the goods to be handled.

Our comprehensive range of storage equipment includes shelving, slotted angle, steel flooring, balcony structures, lockers, cupboards, tables, benches, etc., which provide a ready answer to all storage problems.



The overall sizes of the assembled pallet are 40″ × 27″ × 28″ high but for return empty journeys the pallet can be collapsed as shown above to the dimensions of 40″ × 27″ × 10½″. A space saving of approximately 3/5 cubic capacity.
Capacity of pallets = 10 cwts. evenly distributed, stackable 5 high for warehousing, 2 high on vehicles when loaded.
Construction: Rolled steel angle framework, Wire mesh sides, Sheet steel deck.



RUBERY OWEN

PALLETS

RUBERY OWEN & CO LTD · INDUSTRIAL STORAGE EQUIPMENT DIVISION
WHITEGATE FACTORY · WREXHAM · N. WALES · TELEPHONE: WREXHAM 3566/8

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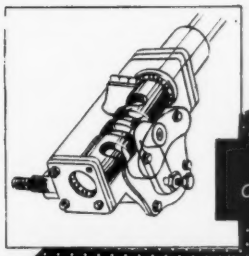
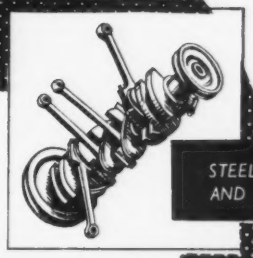
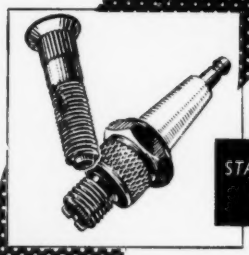


MILD, CARBON AND CASE-HARDENING STEELS

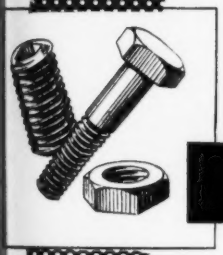


STEELS FOR FORGINGS AND DROP STAMPINGS



STANDARD & HIGH TENSILE FREE CUTTING STEELS

PARK GATE STEELS



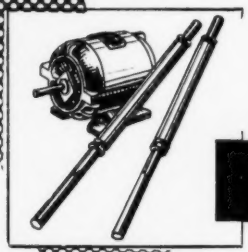
COLD HEADING WIRE

RANGE OF QUALITIES

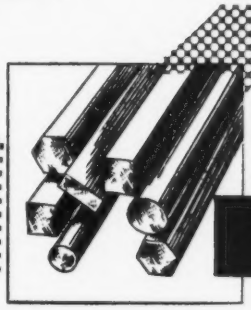
Steels in the carbon range 0·08—0·85%
Case – Hardening Steels
Free Cutting Steels
Low Alloy Steels

RANGE OF PRODUCTS

Billets from 3″ square upwards
Rounds $\frac{3}{8}$″ to 9$\frac{1}{2}$″ Squares $\frac{3}{8}$″ to 4$\frac{1}{2}$″
Hexagons $\frac{3}{8}$″ to 3$\frac{3}{8}$″ Flats 1$\frac{1}{2}$″ to 12″ wide
Coiled Bars $\frac{3}{8}$″ to 1 $\frac{1}{16}$″
Cold Forging Quality Wires
Colliery Arches, Props and Accessories



HARD SHAFT STEELS



MILD, CARBON AND ALLOY STEEL BARS

THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM

A TI Company

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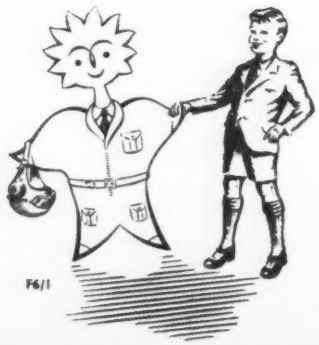

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